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Projects for Science Students

• By E. P. Little, Ph.D. *(Harvard University)*
INSTRUCTOR IN SCIENCE, THE PHILLIPS EXETER ACADEMY, EXETER, NEW HAMPSHIRE.

This is an interesting account of the somewhat unusual manner in which a famous school for boys encourages interest in experimental science.

At Phillips Exeter, participation in extracurricular science activities is wholly voluntary. Instructors do not plan or organize the work of the several science groups. Students must take the initiative, a procedure calculated to develop leadership and a sense of responsibility. Teachers find the work of supervision "a pleasant diversion from the normal routine of teaching."

The mere mention of a few of the projects that boys have undertaken and completed satisfactorily shows the soundness of the method of instruction.

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Louis Agassiz, in 1873, expressed an eternal truth when he said, "Young man, study nature, not books." Today, all too few students have the time or the facilities to follow such advice, and any project which can put a student into direct contact with nature should be exploited to the utmost. Such work can also be most interesting for the teacher as a pleasant diversion from the normal routine of teaching.

In this school we have developed two entirely different methods of encouraging boys to take up extracurricular science activities. On the one hand, all the small groups of boys interested in scientific and engineering subjects are banded together in a Scientific Society. In the Society are eight groups, each of which runs its own affairs within the framework of the Society as a whole. These groups are called the Aeronautics, Biology, Chemistry, Lecture, Meteorology, Model Railroad, Radio, and Shop Groups. On the other hand, a small number of specialists work individually with instructors on projects that interest them. In general, these boys are more advanced and usually are more capable than those in the Groups of the Scientific Society.

The Groups meet separately, usually once a week. At these meetings movies may be shown, an instructor or a boy may give a talk, or a representative of a commercial company may give a demonstration lecture. These meetings are informal and students feel free to ask questions or to take issue with the speaker. Student speakers soon learn the value of careful preparation and a few experiences of this sort develop their self-confidence to a surprising degree.

In addition to weekly meetings, work sessions are conducted as often as a boy's time and inclination permit. An instructor is always available to help a student who runs into difficulty, but the boys are encouraged to work on their own. The meteorology group, for instance, operates a weather station. Readings are taken every day of the maximum and minimum temperatures, the relative humidity and dew point, barometric pressure, precipitation, type of overcast, wind direction and velocity. These readings are posted in the science building on a bulletin board near which is mounted the large daily weather map sent out by the government. Barograph, thermograph, and humidigraph charts for the past week are also kept on the bulletin board, and once a week the summary of the weather of the past week is relayed to the local town paper for publication. These boys are constantly improving the station by developing new instruments such as weather vane and anemometer indicators. These instruments, which are located in the corridor of the science building, indicate the wind direction and velocity on the roof. The theory of air masses and weather problems in general are worked over in the weekly meetings.

The other groups operate in much the same manner. The radio group, for example, has built and operates its own transmitting station, with several licensed operators available. The school has been able to help this group by purchasing some war surplus electronic equipment. The biology group has several members who are dissecting cats, and one who is mounting a chicken skeleton.

All the activities of the members of the Scientific Society are purely voluntary, and the amount of interest in any one group fluctuates from year to year. The total enrollment in the Society, however, remains fairly constant from year to year. At present it is about 145, which is surprisingly large considering that the total population of the school is about 700 students.

The instructors who act as advisers of the groups do not attempt to stir up interest in the boys of the school. That is taken care of at the beginning of the year by general meetings, and during the year by the boys of the Society. However, once a boy or group of boys shows interest, then the instructor plays an important role. He can quietly influence the leaders of the group, suggest projects, obtain equipment, give advice on the work, and talk at the meetings of the group. Instructors are not the organizers of the activities of the groups. These important functions are undertaken by boys, who develop leadership and responsibility under such a system.

More closely supervised is the work of the small group of advanced boys who work out individual projects with an instructor. The problems attacked are

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The Future in Physics

• **By Donald M. Bennett, Ph.D.** *(University of Wisconsin)*
PROFESSOR OF PHYSICS, SPEED SCIENTIFIC SCHOOL, UNIVERSITY OF LOUISVILLE, LOUISVILLE, KENTUCKY

The statement that the recent world conflict was a war of physicists is a familiar one. In a way it is true.

War needs stimulated furious research activities in physics that led to amazingly profitable results. Will the researches be continued on a large scale? If so, along what lines? Who will finance them? Will the war-time discoveries find peace-time applications? Now that industry has learned how much it depends upon physics, will the high salaries it offers attract enough physicists to create a serious crisis in university teaching?

Here a physicist of note discusses some of the possibilities, and points out some of the needs.

A little over half a century ago, the statement was made that physics had reached the end of the road. Scientists had knocked at the door of nature, and had been given all the answers. This universe of ours was no longer a mystery. There were no secrets which remained to be discovered, and the future of physics would have to be devoted to the determination of one more decimal place in the various physical constants.

As we look back upon it, this seems almost to have been the signal for nature to demonstrate to man how little he really knows about this complicated and wonderful universe in which we live. In quick succession were discovered light rays of which he knew nothing previously—the so-called x-ray. Then came the natural transmutation of one element into another through the medium of radioactivity. Thermo- and photo-electric effects made their appearance. The electron lost its speculative character and became a demonstrable entity. A whole new philosophy had to be evolved to take care of the new phenomena, the quantum theory of energy. Then came the theory of relativity, upsetting our existing notions of time, space, matter and energy. Waves took on the characteristics of particles, and particles of waves. Man's conception of the universe changed so violently and so rapidly that it became almost unrecognizable as the same universe so confidently described just before the turn of the century.

Turning from our backward glance over this amazing change in outlook, the temptation is almost overwhelming to look forward, and to ask ourselves "What next?" If we have learned anything from the past 50 years, it is that we cannot predict with any accuracy what new things may be in store. But certain lines of investigation are being pursued, and we might hazard a guess as to where they will lead in the future. The first 40 years of this era have been largely years of discovery and explanation; the last 10 years have been years of development. It is these latter that may furnish a clue to the future.

When Rutherford found that the alpha ray (a very rapidly moving helium atom) could be used as a projectile to be fired into the nucleus of an atom and induce artificial transmutation, one of the great discoveries of the age was made. But he was handicapped by a limited supply of ammunition. So the scientist set his wits to work in an effort to supply other rapidly moving particles in sufficient numbers to make quantity production possible. In rapid succession came the van de Graff generator, the cyclotron, the betatron and the synchrotron. These new instruments have taken charged particles, whirled them to unbelievable speeds, and hurled them into matter. Under the furious resulting bombardment, whole groups of new radioactive materials have been produced. These show great promise of usefulness in biology, medicine, and chemistry as well as in the field of pure physical research. And as the speeds become higher and higher new particles are appearing, the neutron, the meson, and neutrino. Such things had not even been imagined a short time ago. Up to this time the meson has not been produced in the laboratory, appearing only as a result of the enormous energies supplied by cosmic rays. But there seems a good possibility they may soon appear as man-made particles in the laboratory. The neutron has already appeared, and has done some remarkable things to this world of ours.

The theory of relativity pointed out that matter and energy were one and the same thing. It gave no hint as to how one might be changed into the other. But with the discovery of the artificial transmutation of matter, it seemed necessary to bring this theory into the picture to explain the results. Apparently some condition exists in the nucleus of the atom which, under certain circumstances, may change matter into energy, or vice versa. As a result of this, the atomic bomb was produced, with the probability that power plants run by atomic power will be a reality in the not too distant future. So far, these results are achieved by a select few of the atoms. It is not beyond the realm of possibility that other atoms, subjected to the even more furious bombardment which is coming, may join the ranks. We may be on the verge of an entirely new era of power, making the smoke and grime of our cities a thing of the past. And what if some one hits upon a method of transforming matter into energy directly without using the atomic nucleus at all?

Perhaps he will change matter into electrical, chemical, or heat energy by artificially producing the requisite conditions which now exist only in atomic nuclei. If this is done, and if it is a controllable reaction, the entire mode of life, and the economy of the human race will be changed. If it is not a controllable reaction, it is highly probable that no one will be left to worry about it. Before such an event can come to pass, much more must be learned about the structure and fundamental nature of the nucleus. Research along this line should proceed rapidly.

The whole field of radiation shows numerous possibilities. Much is being done with gamma rays, x-rays, ultra-violet, infra-red, heat, and short radio waves. Many fascinating things are coming out of this field—fluorescent lighting, radar, radiant cooking, mutations in living cells—to name but a few. The discovery of the magnetron oscillator with its ability to produce ultra-short radio waves of great power has opened up a whole new field of research into the effects produced by these rays in matter. A great deal should soon be learned concerning the fundamental characteristics of radiation. This, like artificial radioactivity, will probably branch out into medicine, biology, etc.

In the field of sound, supersonics shows much promise. By means of these high frequency waves, energy can be shot at a point, transmitted through tubes, produce burns, and accomplish a host of other miracles. This infant may grow into a vigorous adult with surprising results.

And what about the man who deals in this fascinating field, the physicist? What does the future hold for him? In the past he has been caricatured as an absent-minded, impractical dreamer, shut off from the world and interested only in wires, meters, and gadgets. Will he continue to be so regarded? Here, I think, we can answer with much more confidence. And the answer is "No!"

From the work of the physicist in the past war—a work which has ranged from devising new weapons, supervising their manufacture, installing them in the machines of war, accompanying them on their missions of death as observer and repair man, acting as director of huge enterprises—he has crawled out of his shell, and taken his place in our everyday world. This is shown by the unprecedented demand for physicists today, a demand which seems to be destined to increase in the future. The work of the physicist in this new world may fall roughly into one of three groups: (1) the explorer, (2) the analyzer and (3) the applier.

The *explorer* is the research man in pure science, the man who has an imagination and enthusiasm which enables him to grasp the significance of some group of facts and to envision the path along which they are leading. In the past his work has been supported largely by universities, but now more and more of the large industrial plants and private groups are anxious to join the procession. They have the advantage, in many cases, of large sums of money on hand which will give to the research physicist all the equipment needed for his work. Most companies do not demand that the results of the research be immediately applicable to the particular product in which they are interested. Consequently there is a gradual shift of the important basic research from the academic to the industrial atmosphere. It would seem that this shift will continue, and there will be more and more demand for the research physicist in industry. There may also be set up government sponsored laboratories which, if kept clear of political interference, might make valuable contributions to scientific progress. The whole trend seems to be toward an increase in basic research activity, with much greater freedom and opportunity for the physicist.

The *analyzer* is a relatively new entrant in the field of physics. In times past, the men who have taken the mass of experimental fact and theory and who have sifted it and rearranged it for general consumption have been the teachers in the academic halls. In most cases this has been done with the idea of pursuing historically some particular line of thought in which the individual happened to be interested, rather than making a dispassionate summary of activity and results achieved. In recent years some of the industrial concerns, again, have taken it upon themselves to employ an analyst to inform their own staff (and incidentally many other physicists) of recent progress in physics. It seems almost inevitable that with the greatly expanded research facilities in prospect, with the consequent increase in new information arising therefrom, there will be an also increased need for this type of work. Anyone entering this field must be widely conversant with the problems under investigation; must have an unbiased mind with which to weigh and select; and must have the ability to express complicated ideas in a simple and straightforward manner. Of such materials are the great teachers made!

The *applier* is the man who can observe and correlate scientific laws and facts, and can envision therefrom a method in which they can be used for the improvement of life. At this point the physicist and engineer meet on common ground. During the war, hundreds of physicists were drafted into industry to use their talents in the protection of the country. Many of these men have shown themselves so valuable that they have remained in their war-time positions. Other manufacturing concerns have seen the service these men have been able to render, and have decided to establish physicists in their own laboratories. It seems certain that this demand, also, will grow.

With all these demands on the physicists, the number of them must be increased. This is the task of the educational institution. And it will not be an easy task. A quick glance at the preceding paragraphs will show that industry will need and will absorb the research man, the teacher, and the executive. They will be attracted by the higher salaries in the commercial field. Then fewer of

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Building a Sundial

• By David W. Rial, M.A. *(Clark University)*
FELLOW IN ARCHEOLOGY AND ETHNOLOGY, CARNEGIE MUSEUM, PITTSBURGH, PA.

The charm of a sundial is undeniable. Why not have one? Why not build it yourself?

Mr. Rial gives directions that are concise and clear, and simple enough to be followed even by elementary students.

Would this be a good summer activity for your group?

From time immemorial man has pondered the passing of time, and according to his mood or age, it dragged or "sped on eagles' wings," "slow in its swiftness," or "swift in its slowness." Out of such introspections arose many trite sayings and musings—"Tempus fugit"; "Time and tide wait for no man"—indeed, a whole philosophy of life. "How fast does time fly?" he pondered. "How can I mark the passing of time?" From a welter of thinking evolved the modern accurate timepiece, or chronometer. The early beginnings of time measures and markings, like the first efforts of man in any science, were crude; yet they had a remarkable approximation to accuracy. Witness, for example, the calendars of early Asiatic civilizations or the Maya peoples of Central America. But the simplest of these devices was a sundial.

The charm of a sundial marking the passage of time always seems to hold an interest. The construction of one is easy. It may be as tiny as a Swiss watch or as gigantic as the famous sundial of the World's Fair at New York in 1939. It lends itself to endless varieties of artistic design—"a thing of beauty and a joy forever."

SUNDIAL constructed by the Sisters of Divine Providence at Divine Providence Academy, Pittsburgh, during a summer course in nature study. This photograph, which was taken in early spring, fails to show the beauty of the spot.

If the construction of the dial is a class project, it can lend itself to an endless variety of fascinating experiences, and provide opportunities to change ugliness into beauty. Many times an eyesore, such as an old dump, may be turned into an attractive spot; or the presence of a sundial may enhance the charm of a recreational location. One may use expensive materials and plan the layout with scientific accuracy. Or it may be constructed of waste material, such as a two-inch gas pipe for a gnomon, a length of storm drainage pipe set in concrete for anchorage, and white painted bricks for hour markers.

Suppose we choose to construct a sundial. The first point to be decided is the location. Find a level spot with a clear view to the south, at least one without buildings, trees, or shrubbery to cast interfering shadows. With a compass to guide, set two stakes firmly in the ground about three feet apart in a direct north-and-south line (Fig. 1.) Two by four studding is most suitable. Establish a horizon plane by nailing to the stakes a piece of smooth siding or timber, leveling its upper surface by means of a carpenter's level. Several hours after sundown, with a clear sky for observation, nail to the leveled-up piece another piece of timber aiming at Polaris, the North Star, as one would aim a gun. The angle between the horizontal timber and the section pointed at Polaris is the latitude of the spot. This is true because of a law of astronomy which states that the latitude of any spot on the Earth's surface is equal to the altitude of the elevated Pole. The angle of the elevated Pole at the equator is 0°; of course, the latitude is 0°. At the North Pole the North Star is in the zenith, the latitude being 90°. In the southern hemisphere no guiding Pole Star can assist one in this respect.

A trench should now be dug, about 30 inches long, two feet or more in depth, and wide enough that one may use his arms without interference as he sets a section of the four-inch drain pipe at the same angle with the horizon as the latitude found. The best results are obtained by setting the drain pipe in concrete. After letting the concrete set for a day or two, place a ten-foot length of two-inch galvanized pipe in the drain pipe (a two by two wooden timber may be used, or a two by four, but wood is likely to warp). Use several stones to wedge the iron pipe into a rigid position. Fill the space around the iron pipe with thin cement. Allow it to set

for a day or two. The pipe or gnomon will then be quite rigid. That portion of the construction below the surface may now be covered with soil.

The shadow cast by the pipe at noon will be the location of the twelve o'clock hour, as the sun crosses the meridian. The other hours may be marked, as we have mentioned, by rigorous scientific calculations, but for all practical purposes the points that the shadow should cross at other hours of the day may be identified by using a watch, noting the position of the shadow at the various hours.

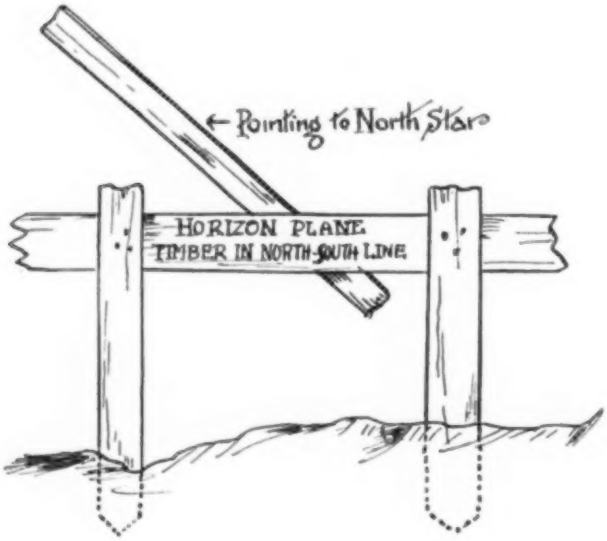

Figure 1.

While it is not necessary that the angle of the gnomon be exactly that of the latitude of the location, the variation from the true latitude should not be more than five degrees or so. It is interesting to observe that the gnomon of a sundial at the poles of the Earth would be perpendicular to one's horizon, while at the equator horizontal to the horizon.

All sorts of markers for the hours may be used. Sometimes they are bricks painted white for contrast, set on edge, and arranged in the circle over which the shadow passes. Sometimes the figures may be cast in cement as Roman numerals, with a mid-marker to indicate the exact spot for the hour. Here again one may exercise his taste. The space around the dial may be a smooth, velvet lawn; or, as is sometimes done, a continuous bloom of flowers is planned, beginning with crocuses or snowdrops and ending the summer with perennial asters or scarlet sage. Near it may be a bird bath or gazing globe, a garden seat, a shrine, or anything one's fancy may choose.

In one nature study camp in which the author was a counsellor, a collection of the wild flowers of the neighborhood was planted within the circle and around the location. It was a continuously restful spot to which one could repair for quiet contemplation, a moment of relaxation, or quiet repose.

PROOF OF THEOREM

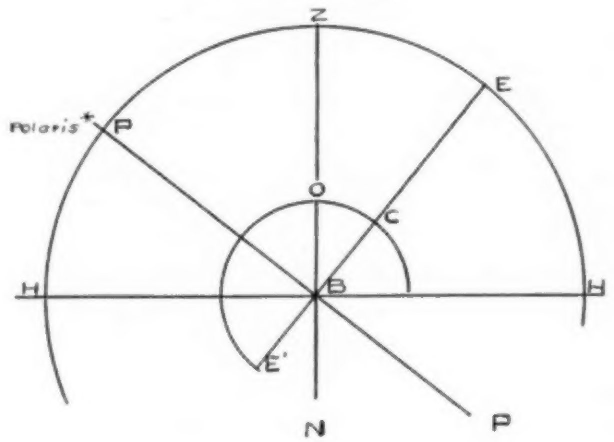

Figure 2

The proof of the theorem stated above, namely, that the angle of the elevated Pole is equal to the latitude of that point, is given herewith.

In Figure 2, **E'E** is the plane of the equator passing through the center of the Earth, represented as the small unfinished small circle. Suppose, because of the immensity of the celestial sphere HPZEH, one considers the Earth as a mere point, B. Then angles PBE and HBZ are right angles. PP' is the Earth's axis. O represents an observer whose latitude is ZE = OC. Angle PBZ is common to both right angles. Hence, angle HBP, the altitude of the elevated Pole, equals angle ZBE, the angle which measures the latitude. Incidentally, the 80th meridian of longitude west of Greenwich passes directly, or nearly, through the buildings of Duquesne University at Pittsburgh.

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"Science to me is the process by which we can, with cooperation, work to understand the process of Nature. The scientists should be open-minded students sitting in the great classrooms of Nature, listening to her lectures, and using this information to benefit their fellow-men."

C. F. KETTERING
Science, December, 1946.

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An anonymous writer in *The Saturday Review of Literature*, Dec. 14, 1946, has this to say of scientists, "that damned type of atomizers" . . .

Scientists all look alike
They have spectacles and sharp noses
Their humor is thick as a dyke
And they pose at having no poses.
Frankly, I will have none of them
Their skill or the Black Death around it;
I venture to say there's not one of them
But left the world worse than he found it.

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Fire Prevention as a Science Study

• **By J. Wendell Sether**
NATIONAL BOARD OF FIRE UNDERWRITERS, NEW YORK CITY

Every minute, day or night, a fire breaks out. Every hour a life is lost; one-third are children under fifteen years of age. Fire losses for the first six months of 1946 ($297,000,000) were greater than for the twelve months of any year from 1933 to 1940.

Yet authorities maintain that most fires and fire deaths are preventable.

Teachers of science are in a strategic position to instruct the young, and through them their elders, how to stop this appalling waste of life and money. This helpful article gives suggestions for such instruction.

Everything man uses or in which he lives and works is capable of being damaged or destroyed by fire. Any building, whether it be of stone, steel, or glass, is vulnerable to heat. Even so-called "fireproof" buildings are only as fireproof as their contents, or the nature of the buildings adjacent to them. Wooden partitions, combustible floor coverings, desks, files, or stored materials are like logs piled up in a stove, waiting only the application of heat to start a blaze. Steel beams will buckle from heat unless heavily protected with concrete. Under certain conditions, concrete will crumble, marble will "spall" or chip, glass melt and break. Heat from even a small fire will cause steel and other metals in fine machinery to lose their temper and be damaged beyond repair.

These facts being recognized, one should also recognize that fire and fire-causing agents in various forms are being used in modern life to a greater degree than ever before. The average home has two or three times as many electric appliances as it had twenty years ago. Devices for heating and cooling—all of which contain some element of hazard—are much more common. We are using more flammable liquids and fuels, and new materials whose characteristics may be unfamiliar to most of us. Since fire, the ever-present servant, is a potential enemy, the training of every citizen should include some elementary facts about fire, and particularly how to control it to prevent its spread.

In science classes there are ample opportunities to teach fire prevention because it can easily be used as a point of reference in any study of chemistry and physics. For instance, a lesson on the expansion of gases might include a discussion of how expanding gases, such as those produced in a fire, contribute to spreading fire throughout a house or school. The rise of heat or superheated air in a burning building is what spreads fire to upper floors; knowing this, students will better understand the necessity for enclosed stairways, self-closing fire doors, and firestops in the walls of our homes.

Many courses of study in fire prevention deal almost exclusively with the causes of fires and how to put them out. A bibliography of such courses and laboratory demonstrations will be noted at the end of this article. But since the basic theories of fire prevention and fire protection frequently are neglected, and since these theories involve well-known principles of chemistry and physics, a discussion of them would have value in science classes. The discussion might follow these lines:

Since fire is the result of the simultaneous combination of a combustible material (fuel), oxygen (air), and a source of ignition (heat), all fire prevention and fire protection are based on the removal or separation of one of these elements from the other two.

Removal of fuel: In practice, this is more commonly done *before* the fire breaks out. We space our houses, we store oil in widely spaced storage tanks, or we place explosives in underground vaults. Then if fire breaks out in any one place, the fuel it feeds on will be as widely dispersed as possible. The fuel is removed from any possible starting point of fire. This ensures that if a fire starts, it will not be a big fire.

Removal of heat: It is far more practical to remove heat from a fire than to extinguish the fire by any other means. Water is the best and the universal extinguishing agent because it has high heat absorption power. It is also most abundant and cheap. It quenches fires by lowering the temperature of the burning material below its burning point. Naturally, the more material that is burning or the hotter the fire, the more water will be required to reduce the temperature. Here is where fire departments call on scientifically trained engineers to pre-determine the amount of water necessary to put out a fire in any given place.

Much of the science of fire protection is concerned with the removal of heat *before* a fire, or rather to prevent its travel from burning material to new fuel. Engineers recommend self-closing doors at the head of basement stairs, enclosure of elevator and stair shafts, and sometimes plaster or gypsum board on basement ceilings, to prevent the escape of heat from a possible basement fire to the upper floors. Fire-resistant partitions, with either self-closing or automatically closed fire-doors are installed in large buildings to prevent the horizontal spread of heat through the expansion of superheated air and smoke.

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Education in Science for Adolescents

• By Rolland M. Stewart, Ph.D. *(State University of Iowa)*
PROFESSOR OF RURAL EDUCATION, EMERITUS, CORNELL UNIVERSITY, ITHACA, NEW YORK

This thoughtful paper deserves careful study, not merely a quick reading.

Like many others, the writer believes that there is much yet to be done in providing satisfactory science instruction throughout all the grades. Education in science should be selective and interpretative of the most likely issues of life. It should not be too formal, nor unrelated to living.

Dr. Stewart makes specific suggestions concerning what should be taught, how the curriculum should be organized, how teaching units should be determined, and how teachers should be trained.

I. Some Presuppositions

In discussing the place of science in education one can be suggestive only, since the scope is great. The public thinks of science in general without reference to its multiple branches. When the purpose is to deal with the educational significance of science, its ramifications are continuous throughout all educational content. If, along with a long list of sciences, English and other languages, the social studies, the vocations, the arts, and health and hygiene, are considered essential divisions of a well-rounded education, then science on its relational side must permeate all the content of the curriculum wherever life situations are involved. In this discussion, though thinking more definitely of the biological, the physical, and the earth sciences, it is not our purpose to limit our perspective.

For the purpose of teaching adolescents it is very important that the connections of science to the world's affairs have priority in science courses. No better approach appeals to youth than reality and its meanings for specific purposes:

1. To acquire knowledge on such a systematic basis as will give understandings of the universe with which our life is concerned, and of our relationships to that universe on a cause-and-effect basis;
2. To acquire similar knowledge on the same basis that will provide understandings of the relationship of the several sciences to the many situations of life in which the facts of science, individually and in sequence, are functional in determining and improving the cultural patterns of society; and
3. To appreciate the procedures in both of the above, as they become essential to interpretive science, and therefore to scientific method.

In formulating and executing a formal program of education that would satisfy the general requirements of the preceding statements and their implications, schools, colleges and universities have not only an important undertaking but a very difficult one. Among these a few may be mentioned: What purposes are to be served and realized by such instruction; how the specific content or substance of instruction may be arrived at, and, therefore, what determinants are valid for the selection of this content; how it shall be taught, considering the varying types of persons presenting themselves for instruction; and how the results of teaching are to be evaluated and measured. Many other questions similar to these and contributory to good science teaching are involved.

The contributions of science—the results from an accumulated body of systematic knowledge, its "method and testing," its relationships to the many and varied cultural and disciplinary patterns of life, its effects upon the social, economic, and vocational competencies of the people—all constitute resources of inestimable value for enlarged and extended instruction in science. The values of these contributions are recognized popularly; however, the massing of great amounts of data, classifying for convenient and desirable uses, organization for instructional purposes, and making it intelligible for persons of less than college grade, constitute a difficult educational task. There is danger that we shall become impoverished in the midst of plenty. John Dewey in his *Democracy and Education*, page 223, refers to this danger.

It is already clear that we are concerned with adolescents. This limitation is imposed for the practical course of discussion. Then, too, this stage of life marks the most significant period for educational growth and development. Following pubescence there is a relatively brief period of a few years when growth and development are accelerated, particularly in the direction of a changed biological pattern. Following this period of more rapid growth, the changes are moderated. The accessory features of the human personality give refinement as maturation arrives. This continuous refinement of growth and development may be extended or retarded according to factors in the environment that favor or hinder dependence of the individual upon the social groups for educational advantages. The advantages of a long period of educational nurture by parents and society are very significant for individual refinement. It is a crucial period for the development of broad fields of abilities, whereby the individual discovers capacities for development of his personality according to broader social and economic patterns. It contributes to creativeness by means of which patterns are improved.

Since the turn of the century the rapid increase in numbers of high schools, in high-school enrollments and attendance, the multiplication of courses of study and curricula, the differentiation of subject matter of instruction in these schools, have demanded of the colleges a more intelligent attitude toward the problems of the secondary school. This attitude is necessary for adequate orientation of enrollees and their classification for advanced educational opportunities at study and experience. It is necessary also for more appropriate curricula in colleges for careers in science. There will be required much more intelligent screenings of secondary-school graduates based upon a variety of factors for the channeling of students onward; also reciprocal services must be performed by colleges and secondary-schools on all aspects of science education. The reciprocal services apply not merely to the high-school graduate who might qualify for entrance to college, but to all groups of students who will need education in science to meet at that stage life's problems as competently as possible. Inevitably it will apply also to the lower schools since science materials are rapidly finding their way in some form in all grades of the schools, designed to give insights into the world in which they live.

It is appropriate that we remind ourselves that enrollments in secondary schools during the last 50 years have multiplied tenfold, and in colleges almost fourfold. This increase for the ten-year period, 1920-1930, for secondary schools, as indicated below, is given for significant age-groups. This shows also the non-attendance for these age-groups. Disregarding the errors of overlapping, of enrollees repeating grades after lapsing by dropping out of school, the record shows that the total increase in numbers of persons of these age-groups from 1920 to 1930 was 836,352.

Attendance by Age-Groups

	1930	*1920*
14, 15		
Attendance	4,102,465	3,114,764
Non-Attendance	501,817	779,903
16, 17		
Attendance	2,637,709	1,637,236
Non-Attendance	1,951,140	2,178,122
18-20		
Attendance	1,440,227	648,955
Non-Attendance	5,255,023	4,112,034

Composite

14-20		
Attendance	8,180,398	5,400,955
Non-Attendance	3,192,225	6,808,020

In the light of the above preliminary statements, one appreciates how education in science for adolescents is "part and parcel" of all education, and also why its aims and objectives must therefore be in harmony with the aims and objectives of general education as a whole. These general aims, though always susceptible to change and to refinement of statement, may be stated briefly in a few categories which are derived from an analysis of the whole of experience in which human beings striving for growth and development find themselves. The social groups must decide what these should be:

1. To promote the growth and development of the individual as far as is practicable; consideration being given to all the factors of the personality as far as they can be discovered—the individual's capacities and abilities, his responses to the reasonable demands made upon him by the groups with which he is associated, his industriousness and initiative, and his amenabilities to principles of balance;

2. To provide opportunities in the activities of home and family life that will develop right attitudes toward members of the family group, and also to the groups with which he may be associated for common welfare; i.e., the individual should have first-hand experience of group relationships in natural-settings as the basis of his own development and of society's welfare;

3. To provide for studies of the social order, its groups and their constitutions, the government and other social institutions, and to maintain opportunities for preparatory experience for induction into the services of these institutions. In our democracy intermediate group organizations are conspicuous and very important;

4. To promote economic and vocational competency in the individual for work and for entrance into work in keeping with the standards of efficiency of the workers in a given area or areas, and to provide the related contributory knowledge that will maintain vocations and professions on a thriving basis.

It is the responsibility of science education to promote these aims by analyzing the various situations of life to see what contributions science should be making; to discover the needs of the people and the resources of the communities for meeting their needs; to locate the difficulties involved, and their frequency and gravity; and to learn what educational means have been set up for improving conditions. It is important also to decide what studies should be undertaken, as far as science is concerned, that will aid the people in their own welfare. Reference has already been made to three major responsibilities to show what their nature is. It is taken for granted that the objectives of science will support the objectives of other divisions of education.

II. Relationships of Science Expressed in Abilities

The value of sciences for educational purposes rests essentially in the discovery of abilities in sciences that are needed to accomplish the major objectives for which it stands. To accomplish such an end in a practical way, the teacher of science must decide what abilities in the learner it is proposed to develop and to what degree. A few suggestions for this task are presented. There are many other types of suggestions that might be made. These will indicate how teachers may discover objectives through a search for desired abilities.

1. *Ability* to extend the range and quality of the learner's sensory experience by means of objective materials and forces,

(1) Such materials and forces as are a part of the educational environment of the school and community, and

(2) Such materials and forces as may be made accessible as a part of the environment by travel or other means.

NOTE: This is characteristically an aspect of self-activity and orientation; *to learn* by observing and doing, a study of the relationships of science to living, the objective forces to be observed in any community. Of these teachers could make long lists.

2. *Ability* to utilize for personal satisfaction in school, field or laboratory, or in practical situations, the raw materials commonly used in science studies, or partly processed materials available in such form,

(1) Selection of appropriate raw materials and objects for the purposes to be served, and

(2) Use and care of instruments for the appropriate modification of these materials and objects, and for their preservation in order for their desired uses.

NOTE: This emphasizes the importance of becoming skillful: (*a*) in making consumer goods, *to learn* how to change the form of the materials or objects to make them serve the purposes, and (*b*) in developing a creative attitude and a way of using one's free time, *to learn* to entertain and educate oneself within the science resources of an environment.

3. *Ability* to appreciate the common science involved in life's processes—in industrial production, in the distribution of industrial products, and in other social and economic activities; also in the procedures of successfully conducted work in science.

NOTE: This is for intellectual appreciation primarily, *to learn* the interdependence of the sciences (including the skills involved in performance), in carrying on the work of science, and to get the satisfaction of making science more significant for oneself.

4. *Ability* to recognize in oneself certain qualities, actual and potential, of dealing with science facts and phenomena thought worthy of cultivation, that are developed readily with science materials as such, in their relationships to social and economic activities, and also to other areas of education.

NOTE: This is also exploratory in part, *to recognize* native abilities in science and to use science materials in new directions, and to appreciate such ability in others.

5. *Ability* to develop a sympathetic understanding and appreciation of the socio-economic relationships of science in the modern world where its uses are universal.

NOTE: This is a socializing and democratizing aspect, *to learn* what other people do, how they do what they do, what contribution science makes to what they do, and how science, itself, is affected by such connections.

6. *Ability* to discern vocational clues involved in science experiences and in scientific knowledge, and to evaluate these for guidance purposes.

NOTE: This provides orientation on a higher level than already indicated, particularly as to vocational careers and choices, *to learn* who are engaged in the sciences and science pursuits, what they do and the relative prospects of work in the different areas.

7. *Ability* to determine patterns and standards of excellence in one's work in the sciences, also in the industries, as well as in other areas where science and scientific procedures are urgent, and to venture into new fields where science applies.

NOTE: This calls for discrimination and distinction, and makes for leadership, *to learn* how to discriminate on a performance basis and to set standards of quality on what one does of a scientific nature, *to recognize* the patterns and standards of others, and *to judge* oneself accordingly.

If we consider the above short list of abilities extremely limited and partial, as they are, it becomes evident that the organization of units of instruction in the sciences that now are taught generally, is a serious undertaking. If we add to these or reorganize them in the light of new developments and new issues of life to which the new science applies, the general and specific abilities of learners in our schools would make a very large order, and very difficult if we sought to provide a well-balanced education in science even for adolescents. This calls for new pioneering in the evaluation of science for secondary schools—a continuous evaluation.

III. What Shall Be Taught

A Preliminary Statement. What should be taught is expressed generally in terms of curricula, courses of study, and units of instruction. Syllabi, outlines, reference to materials and the like constitute aids to bring into relief what needs to be recognized. Curricula, courses of study, and units of instruction are essentially "selective pathways" along which education moves to achieve the aims and objectives of education, and therefore to achieve selected abilities. This is not a new statement but an important one. To attain the abilities desired within this complex of pathways, units of instruction derived from what people have to do in life and what they should know in order to do these things well are essential and basic to advancement in learning. The person who proposes to teach in this area must be aware therefore of what the people do, what they know, and what values they place upon what they do and what they know. He must be aware of what procedures are most effective in acquiring these various abilities, of what outlets, current and potential, for utilization of these abilities are available in life. This is the road to reality in teaching that all students of science must take, and especially the adolescents.

Determinants in Selection. What makes content valuable for instructional purposes? If we consider all of the adolescents in our population, the abilities mentioned above would require classification according to group

(Continued on Page 56)

A New Rocket Engine

• **By John Shesta**
DIRECTOR OF RESEARCH AND ENGINEERING, REACTION MOTORS, INCORPORATED, DOVER, NEW JERSEY

This is a brief account of a new rocket engine which is designed to propel projectiles and piloted airplanes at supersonic speeds. The engine develops a tremendous amount of energy with a minimum of engine weight and fuel, although fuel consumption is high.

Advances in design and construction are being made rapidly. Long-range supersonic aircraft plying regularly between fixed points such as New York and London may become a common method of transportation in the future.

The rocket engine, built recently by Reaction Motors, Incorporated, is a rocket power plant designed to propel piloted aircraft at velocities greater than the speed of sound. Its first practical application is in the Army's experimental supersonic model airplane, the XS-1. Much is expected of it. Although it is the first all-American attempt at building such an engine, it is a masterpiece of modern design. The engine was developed in close cooperation with the Armed Services. Its production involved extensive research and experimentation carried out under the guidance and direction of four American pioneers in the field of rocketry, Lovell Lawrence, Jr., H. Franklin Pierce, John Shesta, and James H. Wyld, all of Reaction Motors, Incorporated.

The relatively small, highly powerful unit may be defined briefly as a liquid propellant regenerative rocket engine which develops almost instantaneous total thrust upwards of 6000 pounds, or fractions of total thrust in increments of 1500 pounds. To present a clearer conception of thrust, it may be stated that at 375 mph, thrust is numerically equal to horsepower. In contrast to the high output of the engine are its relatively low weight and small size. It weighs only 210 pounds, and occupies a space of approximately 19 inches in diameter by 56 inches long. Its installation in aircraft requires only a few minutes. The only connections that need be made consist of attaching the engine to the airframe at four mounting points, attaching the two propellant feed lines to the manifold inlets on the engine, and connecting the electric lead wires into a standard socket on the engine control box.

The engine consists basically of four combustion cylinders plus the necessary piping, wiring, and controls, supported by a single main beam assembly. With minor exceptions such as piping, wiring, and the control box, the entire unit is constructed of high grade, stainless steel. The major components of the engine are almost entirely of welded construction.

The engine operates from the controlled combustion of a fuel and an oxidizer. An alcohol-water mixture is the fuel, and liquid oxygen is the oxidizer. These propellants are injected under pressure into a combustion chamber where they are thoroughly mixed and ignited. The rearward expulsion of the combustion products through the nozzle in the form of a jet of hot gas develops the forward thrust.

From the appearance of the engine, or from the brief description given here, one may get the impression that the development of the engine was a simple task. Actually, a rocket motor is a simple power plant. Our rocket engine is designed, however, with rigid specifications for compactness, controllability, endurance, reliability, safe-

LIQUID PROPELLANT, REGENERATIVELY COOLED ROCKET ENGINE operating on a test stand and firing 30° upwards.

ty, etc. The engineering problems involved in controlling its vast power in so small a space were intricate.

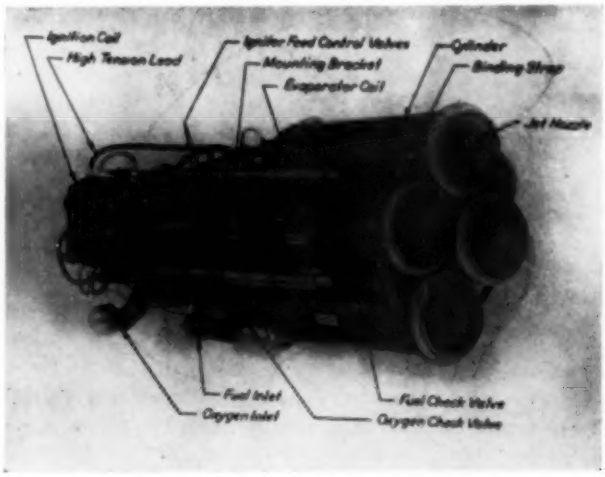
The major components of the engine are: the main support beam, the control box, the propellant manifolds (fuel and oxygen), the propellant valves (of which there are two types—fuel and oxygen), the igniters, and the combustion cylinders. The main beam assembly, as its name implies, is provided to support all the other components as a single unit. All phases of the operation of the complete power plant are actually regulated by the "master-mind" control box. The fuel and oxidizer enter the propellant manifolds from their pressurized tanks. Their pressure regulated by the propellant valves, the propellants flow to the combustion cylinder where they are mixed in the injector and sprayed into the combustion chamber. The igniter, itself a miniature rocket motor, sets off the mixture, and the resulting mass of hot gases forces itself out through the exhaust nozzle with a terrifying roar and at the tremendous velocity of about 6500 feet per second. Theoretically, in the exceedingly thin upper atmosphere an aircraft could be propelled at the speed of the jet.

Combustion in the rocket motor takes place in the combustion chamber at a very high pressure. Because of this, and because of the energetic nature of the propellants used, a rocket motor develops intense heat (4500-5000°F.) on the combustion cylinder walls. To offset this, the combustion cylinders are designed so that the liquid fuel, before entering the combustion chamber, passes between inner and outer cylinders. The fuel cools the walls and, in turn, the heat from the walls tends to evaporate the fuel before it is injected into the combustion chamber. This principle is known as regenerative cooling, because the heat absorbed by the fuel is returned to the combustion chamber. This method of cooling is so effective that the stainless steel nozzle and combustion wall do not suffer any erosion or overheating even after several hours of operation. The external temperature of the cylinders rarely exceeds 140°F.

Since alcohol and liquid oxygen do not ignite spontaneously, an igniter has been developed to initiate the combustion. The igniter is a very small rocket motor attached to the head of each combustion cylinder. It is fed the same propellants as the main combustion chamber. It is started with a spark plug and may be turned on or off at will.

One of the requirements in designing this engine was that it should be capable of repeated starts and stops in various attitudes, including firing with the nozzles pointing 30° upwards. To comply with these requirements, a special injector had to be developed. This difficulty was overcome, and the engine can now be started easily in any position. In fact, positive ignition has been obtained even when the combustion chambers of all the cylinders were tilted up and filled full of water previous to starting.

Many other functional problems had to worked out. Control valves and other accessories had to be designed especially for the engine. Production methods were used



FOUR-CYLINDER, 6000 pound thrust, liquid propellant regenerative rocket engine. Three quarter nozzle-end view with the major components indexed.

wherever possible, so that when the prototype proved satisfactory, additional units could be manufactured as required.

It is a curious fact that, in the field of rockets, the speed of development is closely related to the speed of the rockets themselves. Despite numerous improvements since our rocket engine was first manufactured, we consider it as but one phase in the development of rocketry. To one who has been closely associated with its engineering it gives great satisfaction to know that our engine will power the first man-carrying supersonic aircraft in this country. ●

SUGGESTED READING LIST

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3. *Aviation. January* VTDG. "*RMI's Rocket Engine Which Powers XS-1*".
4. *Air Trails and Science Frontier*. March 1947. "*Streamlining the Pilot*", and "*Robert Report*".
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7. *Life*. 6 January 1947. "*Supersonics*".
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★ ★ ★ ★ ★

"The correctness or adequacy of the solutions of problems will depend upon the use made of generalizations, which, moreover, constitute the essence of scientific knowledge. Their acquisition, therefore, must occupy an important place in general education if it is to develop and make functional the learner's skill in reflective thinking."

EDWARD F. POTTHOFF
Journal of Higher Education
October, 1946.

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The Principal Talks to the New Teacher

• **By Mary W. Muldoon**
PRINCIPAL, WAVERLY JUNIOR HIGH SCHOOL, WAVERLY, NEW YORK

The Author says:

"This paper embodies years of experience in helping young teachers to get started on their first jobs. Experienced teachers may skip it without compunction. It is presented in the hope that it may be of use to the June graduates of 1947 who will be doing their first teaching in secondary schools this fall."

The Editor says:

"Even the most successful teacher will find food for thought in this helpful article. It contains valuable suggestions—some of them unorthodox—about planning the first hour's teaching, lesson plans, school house-keeping, objective teaching, "selling" the subject, and other procedures and problems that may trouble the uninitiated."

"You have signed a contract for a September position in a new community. On the opening day you find your room without crayon and erasers, and the ink wells unfilled. Some of your pupils have fountain pens, a few have pencils, more have ordinary pens, and some no writing materials at all. Before the last bell rings the office has sent you 36 people for your 33 places, and some of the larger boys are squabbling under cover for the rear seats. No texts have been sent in, and the office reports that none will be available before the end of the week. What should you do?"

This question for discussion was the opener for one summer course given by the writer. Though the situation had been purposely exaggerated, that class numbered several young teachers who said that all the circumstances had been duplicated in their own experience. Even with these people included, the class suggested and discussed, argued and counter-argued for some time before one boy, evidently with a little inborn teaching ability, looked up to say diffidently: "Maybe you should have been around the day before?"

Right! Exactly right! But better the week-end before, and better yet the June before, if possible. The novice, the recent graduate, the candidate taking his first out-of-town position not only would be willing to do this, he would be exceedingly anxious to, if he realized now—as he surely will later—that his most important teaching day is his first day; his most important hour is his first hour; the most important part of that hour is its first few minutes. Only too often the beginning teacher is made or broken at the end of his first teaching period.

To insure success, that beginner should plan not only exactly *what* he is going to do during his first day, but also *how* he is going to do it. He should be so familiar with his plans, so confident of his method, that he knows he can do what he has planned with little reference to his notes. If he knows what he is going to do, *and knows that he knows it*, his students will quickly realize it also. This means that he has already won half of his first skirmish.

But suppose you object, as some of that summer class did, "What difference would it make if he did get around previously? In some schools the janitor fills ink wells and installs supplies only on order from the office. A teacher would not be able to get texts, either, if there were none on hand."

Even if the worst were true, that beginner would have known it in advance, wouldn't he? *He could have been ready for it.* When he came that first morning—at least 30 minutes before any student might be expected to appear, so that he could take care of any unexpected, last minute problems—he would be able to bring a small box of crayon, purchasable at any stationer's; some dust cloths that could double as black board erasers if necessary; at least 50 cheap lead pencils, already sharpened; a blotter or so; a box of cheap white paper, typing size—mimeograph stock is good enough; some rubber bands; a few rulers; a pair of scissors; a bottle of fountain-pen ink; and anything else that he might possibly need, or the want of which might upset the progress of events that first day.

Who will pay for these? If you are one of the few teaching candidates to whom that item appears important, you'd better drop out before you begin. The kind of person unwilling to make a small investment of this kind to help insure his own success will never make a teacher. All these things should be furnished by the school. Later, undoubtedly, they will be. If they are not ready now do not let the lack of them spoil your own start. Buy them yourself and use them; explain in class the regulations regarding supplies and give the list of those needed; after use, have your own material collected. *Do not give it away.*

These materials that you brought in will enable you to have registration blanks made out, if they have not been made previously; they will make seating charts easy; they will help record issue of books and supplies if any are available; if your students remain for class work the first day, you can begin actual teaching and have students take notes, regardless of the lack of texts. In short, you will be able to keep your pupils profitably busy, and out of mischief. There is a quick and efficient way of doing all of these things. Make no mistake about it, the fact that your way is, or is not, quick and efficient will register immediately with your student body.

Suppose we begin by charting seating. Before the class entered we had cut enough of our large paper into half sheets to supply the room; counted the slips into

piles, each just sufficient for one aisle; and criss-crossed the piles to separate them, so that one pile could be placed on the front seat of each row in a jiffy.

"Will the student in each front seat place one of these slips on every desk in his row?—Done?—Take your slips. Turn them horizontally like this.—Write your name across the top, first name, middle name if you have one, last name. Under your first name write the word 'Row' and stop.—All the students in this row write capital A after row; next row, write capital B; next row, capital C" and so on. "Now under the word 'Row' write the word 'Seat'. Watch me as I count. The people in this line of seats write 'Seat 1'; next line write 'Seat 2';" and so on to the rear. "Now check your work: It should be: 'Name—your name; Row—your row; Seat—your seat. Any questions? Put your slip on the right hand side of your desk. People in the rear seats please collect. Take these same seats tomorrow, and until I assign you permanent ones, which may not be for several days." Entire time used, from two to three minutes. Possibility of confusion, nil.

It takes from three to five minutes more in your first vacant period after dismissal to enter these slips by row and seat on your seating charts. If such diagrams are not furnished by your office, make your own in another two or three minutes with a ruler and a pencil. Seating charts are aids in keeping track of students; in locating papers, texts issued, damage done to desks and the like; but they are chiefly valuable at this time in making your pupils stay put until you can learn their names. After the first day they furnish a teacher the quickest way of checking attendance. With a seating chart before you, the vacant seats in the room show up instantly, and take only a few seconds to record. Never waste time in "calling roll."

Seating charts should probably be done first because they are so simple, and because they are practically indispensable. If there are home-room-register or office registration sheets to be made out, we follow the same plan for distributing them, prefacing it by saying, "We shall make these out together so they will be uniform. Please do not write anything on the blank until after I have given directions, so we shall not make errors." If, as is usual, the first item is *Name*, tell them whether to put surname or Christian name first. If this direction is printed on the blank, *ask* them instead, but call attention to it. You may find it necessary—and if so, make it interesting—to teach the terms "surname" and "Christian name" from the board as new vocabulary. Under "Age'" and "Year of birth" the latter may give trouble, and frequently does. If so, show how to find it and to check it.

There are almost sure to be children from broken homes in your class. To prevent embarrassing questions about the item, "Parent's or Guardian's name," preface it by stating: "If you live in the same home with your father, write your father's name; if you live in a home with your mother only, write her name; if you live with your grandparents, or some other relative, write that name, and after it in parenthesis put the relationship, as aunt, uncle, cousin, or the like. *If you have a legal guardian appointed by a court* write that name, and mark it "Guardian." These points above almost always cause difficulty. There may be other puzzlers on your blank, but they will not give trouble if you study the blank and prepare for them. Remember always that it is easier to prevent confusion than to correct it.

At the end: "Put your papers on the right hand side of your desk, **face down.** People in the rear seats please collect." Why "Face down?" What they have written is no one's business but the school's. Children from broken homes are often unduly sensitive about it. Why "Right side of the desk?" We do things to make it easier for others, and also we are training these pupils to be prompt. Why "Collect" instead of "Pass your papers forward"? Choice of such procedure is a matter of personal opinion, but for the beginner this method is recommended as being less liable to cause confusion.

Unless your school provides a formal "Book Card" upon which to register its free texts, informal slips for the books you issue may be made in the same way you filled seating charts, and are evidence of the student's indebtedness, to be preserved until he returns the text. Another item to be cared for in your first period is the directions for fire drill for your own particular class. Exits to be used, routing, and any other regulations, may be placed on your board or given orally, but you must make sure they are understood.

Why should the newly appointed teacher also take pains before school opens to see his home room, or his recitation room, or both if he works in both? Why should he look over the study hall if he is to cover study hall periods? For one thing, to get an idea of the arrangement of his audience, and to select his vantage point for teaching. If, as the writer recommends, he makes it a rule to teach from the board and not from a book, there is always one slate in the room that is the best for teaching purposes. It will be on the side opposite the windows, and probably toward the front, placed so that it can be seen from every seat. It will be in a spot where the instructor's body and arm will not hide it from the students when he writes, though he must also learn at once to write standing at one side of that slate, *watching his class*, not what he is writing. That sounds like a hard matter, but the trick grows easy after a little practise.

The first thing the beginner learns from looking at his class room is where he plans to stand for teaching. In the study hall he will select the points from which he can best observe the room. If he is sensible, for the first few days he will observe it from upon his feet, and not from a desk chair. In any event the beginner should be on his feet the first ten and the final ten minutes of every study period. These are the times when trouble usually starts if it starts at all.

(Continued on Page 61)

The Place of Science in General Education

• By Rev. Thomas J. Quigley, Ph.D. *(University of Pittsburgh)*
SUPERINTENDENT OF CATHOLIC SCHOOLS, DIOCESE OF PITTSBURGH, PITTSBURGH, PA.

Is science rightly a part of general education or should it be studied only to develop individual abilities and interests?

How much and what kind of science should be included in primary and secondary school curricula? What criteria shall be used in its selection? Do our science textbooks need rewriting?

The widely-know author of this paper is one of the most progressive young leaders in the Catholic educational field.

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The American philosophy of education continues to demand equal educational opportunity for all its citizens. In recent years, however, we have recognized that this principle does not imply that everyone should have identical educational opportunities. The necessity of combining educational democracy with the unassailable fact that education is a selective process, has developed a real controversy regarding the relative fields of general education and special education. The controversy is concerned with the definition, nature, and scope of general education as opposed to training for specific fields. It is concerned also with the extent or amount of general education necessary as a foundation for citizenship in American industrialized democracy.

The issue may be somewhat clarified by the use of two words highly acceptable in education circles, namely, integration and differentiation. General education may be described as that which integrates us as a nation. Special education differentiates us by developing our individual abilities and interests. General education is education in all those things which everyone does by reason of the fact that he is a human being, a citizen of the United States, and living in the year of our Lord 1947. It includes the translation of our social inheritance, the development of essential skills necessary in any modern life, and the appreciation of the moral, spiritual, and aesthetic values essential to complete living. This "education for integration" includes ideas, skills, attitudes, and habits of life, just as necessary to the attorney and physician as they are to the salesgirl or steel worker.

Special education is education in those things which some of us do by reason of our native talents, interests, and environmental forces. The content matter of the law school or the medical school is special education. So, also, is the learning of skills involved in automotive mechanics, the higher mathematics necessary to the electrical engineer, the shorthand and typewriting in secretarial schools, and the theology of the seminary. This is not to infer that higher mathematics, typewriting, and theology have no place at all in general education. The debate turns about how much and what kind of material from these specialized fields is necessary for general living.

Obviously the entire controversy cannot be treated in a short article. We are concerned here only with the question of the natural sciences and their place in the curriculum of general education. Even this topic cannot be treated adequately. It can only be touched upon in such a fashion as may encourage further thinking about the problem.

Undoubtedly, science belongs in general education. *This* is a scientific age. The method and the findings of modern science affect our general living in a thousand different ways. No one can live effectively today without some knowledge of science. Yet it must be evident that materia medica and the more involved processes of organic chemistry have no place in the content of general education. The question proposed is how much science and what kind of science should be included in the elementary and secondary grades of the common school.

The selection of material for the curriculum of the common school is based on certain definite criteria. Among these must be included three of special importance. First of all, the material must have significance for immediate use on the grade level where it is placed. It must not be beyond the grasp or completely foreign to the possible experiences of the pupils to whom it is offered. Secondly, it must have significance for adult use. This is not to say that everything learned in school must find a place in the adult life of the students. It would be ridiculous to expect such a result, for no one can foresee what changes may take place in our lives from one generation to the next. What is being learned today in school may have little or no practical value in a new age. However, the selection of materials for use today, should be made with some thought to their present usage in adult life. Thirdly, material selected should be significant for a better understanding of the entire field of learning. For example, one cannot place in the school curriculum everything that man has learned about biology. Those materials which are selected should be such as will develop an understanding of the fundamental laws of biology, and inspire an appreciation for the whole contribution of biology to better living.

With these criteria in mind we are better able to criticize the content of science courses devised for gen-

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Rubber . . . Natural and Synthetic

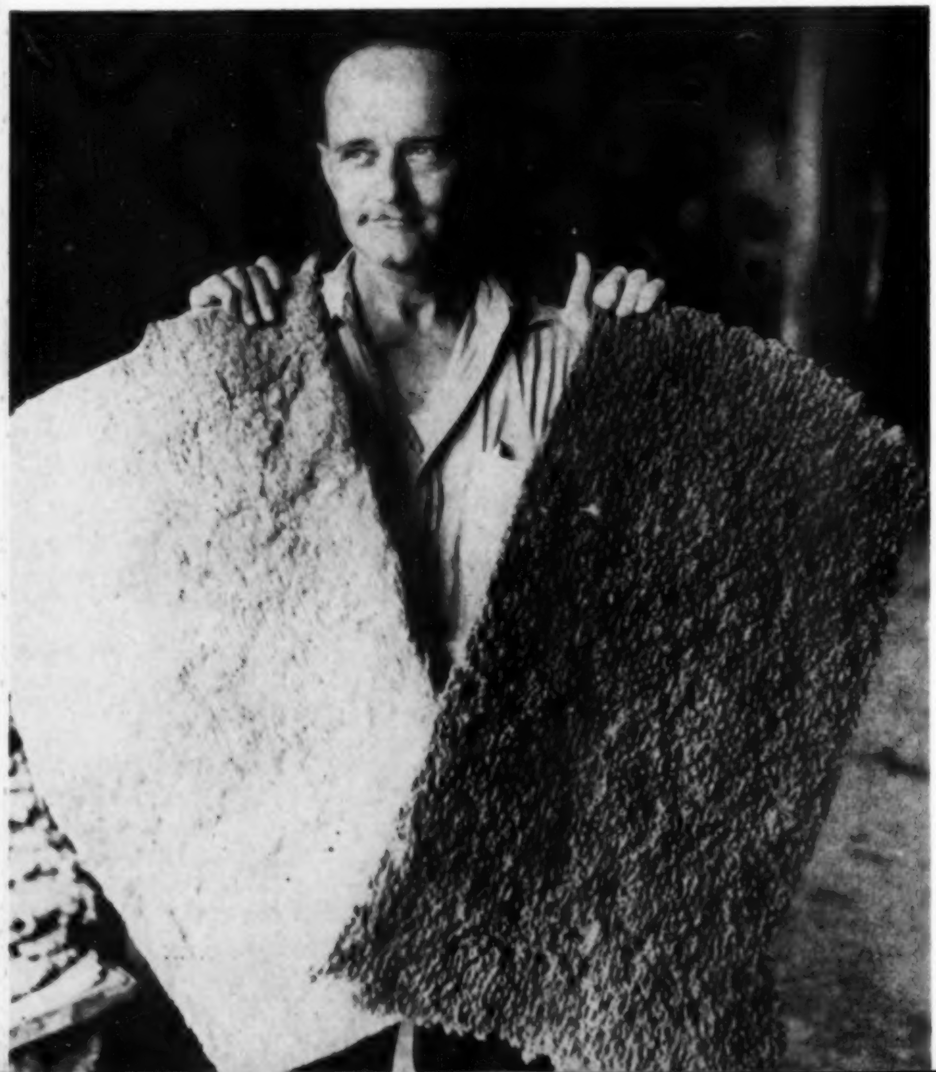
• By Robert E. Powers
THE B. F. GOODRICH COMPANY, AKRON, OHIO

Japanese seizure of rubber producing areas in the Far East forced American scientists to speed their researches on synthetic rubber substitutes, and manufacturers to devise ways of making them on a scale large enough to serve the demands of war and civilian needs as well. That a dangerous situation was met so capably reflects great credit upon our chemists, engineers, and industrialists.

In our March number Mr. Powers discussed natural rubber. Here the emphasis is on the synthetic products, which for some uses are equal to, or even superior to, natural rubber. Some interesting statistics are included.

Part II. SYNTHETIC RUBBER

SYNTHETIC RUBBER comes from the wash mill in flesh-colored sheets. The drying operation changes the color to a light amber. A workman is shown holding a sheet of dried synthetic rubber at left, and dried natural rubber at right. The rubber is washed crude No. 1 Smoked Sheet, and like the synthetic is raw or unvulcanized at this stage. The corrugated surface is imparted by the wash mill operation. (Acme Photo)



A white, unsaturated solid when isolated in its pure state, the hydrocarbon of natural rubber is essentially a polymer of isoprene, represented by the chemical formula $(C_5H_8)_n$. This was first revealed by Michael Faraday, famous British scientist, in 1826. Relatively useless to man in its natural state, when compounded with other materials it possesses the versatile properties of softness, toughness, elasticity, impermeability, adhesion, and electrical resistance. The asset which makes it unique among all materials yet discovered is that of returning to its approximate dimensions after being repeatedly stretched to many times its length or width. It is soluble in carbon disulfide, carbon tetrachloride, turpentine, ether, gasoline, benzene and other aromatics. Rubber products can be made flexible or extensible, waterproof, relatively impermeable to most gases including oxygen, an electrical and thermal insulator, highly resistant to abrasive wear, resistant to the action of most chemicals, and with high frictional resistance on dry, and low resistance on wet surfaces. Three regions of the tropical zone in the Indo-Malay territories, in South America, including the West Indies, and in Africa, including Madagascar, produce practically all the natural crude rubber, with the Far Eastern plantations pouring forth an estimated 97 per cent in the years before the start of World War II. All these major producing areas are in a belt approximately 1400 miles wide encircling the earth at the equator and lying between latitudes 10 north and 10 south where moist, warm climates prevail throughout the year.

Some years after Faraday had come forward with the first chemical analysis of rubber, scientists discerned that rubber is a state of matter in which from 1000 to 3000 isoprene units are joined end to end in each molecule much as paper clips might be linked to form a chain. Isolated scientists began to speculate on reproducing the structure of the rubber molecule by synthesis, and certain experimenters like Tilden, 1888, made and described rubbery products. But these attempts, although they contributed to technical knowledge, always ended in failure because the isoprene units just did not link together in the test tube in the identical manner in which nature joins them chemically.

It was not until recently, when efforts to duplicate the exact composition of the

rubber molecule were virtually abandoned and concentration focussed instead on efforts to parallel its physical properties, that significant progress in the field of synthesis began. Activity, too, waxed and waned with the fluctuations in the prices for natural rubber, being accelerated when prices soared, and decreasing when plentiful supplies of natural rubber were available. Political and military emergencies at various times in different countries often spurred these efforts. The first really significant contributions in this field came in the period 1910 to 1913 when Richard Earle and L. P. Kyriakides of the Hood Rubber Company, now part of the B. F. Goodrich Company, discovered ways to polymerize isoprene, butadiene, dimethylbutadiene and other conjugated diolefins, which, when vulcanized, possessed many of the physical properties of the natural molecule while still differing in chemical structure. They also developed methods of making butadiene, the major material in two of the five major types of synthetic rubbers which have assumed commercial importance in the last 20 years.

Right here it is well to point out that in discussing synthesis it is erroneous to think of synthetic rubber in the singular, because there is not one, but literally thousands of man-made rubbers. Of these a quintet has been found—because of the availability of raw materials, feasibility of the processes by which they are chemically produced, and physical and chemical properties of the finished products—to be the most practical for manufacture and use. In the Goodrich laboratories alone, 14,492 synthetic rubbers were made before Pearl Harbor, and an additional 10,000 since then. All but a few were, of course, only laboratory samples; but this gives an idea of the vast scope covered.

There are four widely-used commercial types of American synthetic rubber. They are: (1) *General purpose*, known in the government's rubber program as GR-S, a co-polymer of butadiene, C_4H_6, and styrene, $C_2H_3(C_6H_5)$. This is the type which went into tires and most other products when the natural rubber supply was shut off.

(2) *Oil resistant nitrile type*. These, which are known as specialty rubbers, are co-polymers of butadiene and acrylonitrile, or vinyl cyanide, C_2H_3CN.

(3) *Neoprene rubbers*, co-polymers of chloroprene, C_4H_5CI, also oil resistant, specialty type.

(4) *Butyl rubbers*, co-polymer of isobutylene, C_4H_8, and small amounts of other unsaturated hydrocarbons, such as butadiene, or isoprene, C_5H_8. Used principally in inner-tubes for tires.

In addition, there are many other specialized types, including the Thiokols, the silicones, Noripol, and a host of synthetic elastic materials with many rubber-like qualities, like the well-known Koroseal and other vinyls. These are all developments of the last two decades.

Synthetic rubbers first came into world-wide prominence during World War I when the Germans, deprived of natural crude, made tires and other products with a synthetic derived from dimethylbutadiene based upon acetone, but its performance was disappointing. Interest was stimulated, however, and following the war scientists, particularly in the United States, Germany, and Russia, made discoveries with butadiene as the basis which proved important. Out of these came the so-called Buna rubbers of the Germans, SKB rubbers from the Soviet, and the American type which differed from both in physical properties and processing characteristics, all of which had butadiene as the principal starting material but differed in the processes of synthesis employed.

The Neoprene rubbers were the first of the synthetics to be commercially produced in the United States (1931), then the Thiokols, followed by the oil-resistant butadiene types. Development of butadiene rubbers for tires, tubes, and hundreds of other purposes in what are known as industrial rubber products, was intensified when war began to threaten. As is generally known, they were rushed to completion in the United States under a combined program of government and industry when the Japanese seized practically all the natural rubber producing areas.

In fabricating synthetic rubbers, the requisites are first, processes which synthesize the molecules to be joined; second, linking these molecules together so that the ultimate material will have the physical characteristics of the rubber desired. Since it is impossible for space reasons to go into detail on each of the processes for the five commercial types of synthetic rubber, and because the butadiene-styrene type has been the most fundamental in the United States' program, a description of the methods employed in making this type will suffice.

Butadiene is a flammable gas which can be readily liquefied by compression and cooling. It must be highly purified for making rubber. Styrene is a liquid that looks and smells like benzol, which is natural since it has a coal-tar base. Butadiene may be prepared from petroleum, alcohol, or any one of several gases, including butane and acetylene, by different methods. The principal material used in the United States' program is petroleum, although alcohol from grains was a major source until after V-J day.

In the preparation of American butadiene-styrene rubber liquefied butadiene is mixed with styrene, soapy water, and several other ingredients, one of which is a peroxide which initiates the polymerization by acting as a catalyst. To avoid undesirable, uncontrolled polymerization, which would yield products not up to specification, a "modifier" is added so the molecules will link as they should. The mixture of butadiene, styrene, soapy water, modifier, and catalyst is heated moderately and agitated under 70 pounds pressure. As the process reaches its conclusion, about 70 per cent of the molecules of butadiene and styrene join to form an emulsion of microscopic particles of synthetic rubber, which looks and acts much like the natural latex from rubber trees.

The latex is then stabilized by a chemical to protect the polymer from deterioration, and the surplus of butadiene and styrene which has not reacted is removed by heating. From here, the process of making synthetic rubber is much like that of producing natural crude. The latex is coagulated with an acid to give curds, which are then filtered, washed, dried, and pressed into bales for shipment to the rubber factories making the finished products. An interesting sidelight on this process is that during the peak of synthetic rubber production in the United States, approximately seven per cent of all the soap made in this country went into synthetic rubber manufacture. All ingredients must be controlled to high levels of purity.

Once in the rubber factories, both natural and synthetic rubber go through the same processes, with modifications, of course, in being made into tires or other goods. The bales, after being cut to convenient size, are thrown into huge mills or plasticators where the rubber is made plastic enough to blend with the compounding ingredients necessary for the specific purpose which the rubber will serve. It is then milled until all these ingredients are thoroughly dispersed throughout the batch. In this form it is ready to put through calenders, as a coat for fabrics of various types, or to form sheet or film; or it is put through extruders where it is formed in the sizes and shapes needed for subsequent operations. Rubber-coated fabrics are used in the manufacture of tires, belts, hose, and many other products, most of which are built up, ply upon ply. Sheet and film find their way into other types of products, as do the pieces which come from the extruders. Regardless of their ultimate service function, all products, after they have been built, must in the end go to the vulcanizers of various types, where under heat, sulfur reacts with the rubber and sets the compound to do the job for which it is intended.

Crude rubber imports from the South American and African jungle regions into the United States were but a trickle for many years after our traders found the material available, and even after it had been made practicable for commercial use the increase from year to year was very slow. There are but fragmentary records of the imports during the earliest years, but in 1870, when the Goodrich Company established the first rubber plant west of the Allegheny mountains, the total consumption of rubber by United States processors was only 4000 long tons. During the succeeding three decades, rises in consumption continued annually, but at a slow rate so that in 1900 the nation's rubber plants turned 20,000 long tons into finished products. This was an average increase of less than 1000 long tons yearly.

It was soon after the turn of the century that automotive transportation really started to make its impact felt on every phase of life. The pleasure car, developed in this country in the decade previous to 1900, began to be looked on as a means of transportation for the multitude rather than the plaything of the rich; busses and trucks began to roll in ever increasing numbers, and the nation's improved road systems began linking up cities, towns, villages, and the surrounding countryside.

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GOVERNMENT (GR-S) RUBBER PLANT operated by B. F. Goodrich Chemical Company at Port Neches, Texas. (Photo Elwood M. Payne)

Elements of a Functional Program in Mathematics

• **By William Betz,** Rochester, New York

This paper will challenge your careful thought.

It concludes the frank discussion of the teaching of mathematics which was begun in our March number under the title "Functional Competence in Mathematics." The first paper showed that mathematics may be viewed as an objective system of ideas, as an objective body of related applications, and as a subjective area of learning. All three have been considered in building the truly functional mathematical program for the average pupil which is suggested here. What do you think of it?

Noted as teacher, author, and lecturer, Mr. Betz was called upon recently to participate in the work of the Commission on Post-War Plans in Mathematics. He has been President of the National Council of Teachers of Mathematics and a member of the Board of Governors of The Mathematical Association of America.

The Curriculum—Constants and Variables. Perhaps the most authoritative recent pronouncements on the mathematical curriculum are found in certain publications listed at the end of this article.[12] In the following paragraphs they will be referred to by number in the given order. The general picture we derive from these three documents may be outlined briefly as follows:

1. We must have a *continuous* program in mathematics extending from the kindergarten to the junior college.

2. In grades 1-6 the pupil should acquire reasonable proficiency in computation with integers, fractions, and decimals, should become acquainted with the common geometric figures, should learn about the principal units of measurement, and should be able to solve simple problems illustrating and applying the related concepts and skills. See (1), p. 54; (2), pp. 199-203.

3. Grades 7-8 should offer an intermediate program comprising a further study of arithmetic, the basic elements of informal geometry, the use of formulas, graphs, and simple equations, together with the beginnings of indirect measurement, all of it accompanied by a constant emphasis on related "life problems" and applications. See (1), pp. 82-86; (2), pp. 203-205; (3), p. 162.

4. Beginning in grade 9, we should have a *two-track program*, as follows: (1) a distinctly sequential and thorough presentation of those elements of "academic" mathematics which are needed as a foundation for subsequent studies and for cultural orientation; and (2) a course in general or basic mathematics which relates its mathematical ingredients more directly to immediate use in everyday life. See (1), pp. 99 *ff.*; (2), pp. 205 *ff.*; (3), pp. 162 *ff.*

By way of implementing this program, the Commission on Post-War Plans offers a noteworthy Check List of 28 items, comprising the "essentials for functional competence in mathematics." (See (2), pp. 197-198.)

One important observation found in the Joint Commission Report (pp. 17-19) is still being overlooked by critics of the traditional program in mathematics. In describing "the *dual* aspect of the curriculum," the Commission states that the curriculum is composed not only of relatively permanent but also of fluctuating elements. These correspond to the "permanent features of our existence" as compared with the "adjustments demanded by each successive age." As a system of ideas, mathematics is a fairly *constant* domain. But as a body of applications it involves *variables* which reflect the progress of a changing civilization.

The Pupil—Normal and Otherwise. The learning process represents the *subjective* element of the curriculum. The three reports mentioned above agree in giving considerable attention to this phase of our problem, and hence to the *pupil*. Today more than 25 million pupils constitute the population of our schools, of whom approximately 7 million are in the secondary schools. This immense enrollment has come upon us with such rapidity that it would be very strange indeed if it had not caused the many headaches of which we constantly complain. No other country in the world has a democratically organized and unitary system of education comparable to ours.

The central fact we must now consider is that the pupil, too, is a "variable." What does this mean?

In statistical terms, it means that when a *large number of natural objects* of the same type or class, *chosen at random*, are studied with reference to specific traits or qualities, we are likely to obtain the kind of distribution found in a "normal curve of variation." From this starting point enterprising psychologists have led us on to the concept of the "normal child," then to the theory of the I.Q., and finally to the techniques of standardized intelligence tests, achievement tests, aptitude tests, and so on. For certain purposes this new machinery is not

without value. It has given us the device of "homogeneous grouping," has initiated more careful studies of the learning process, and has caused a decided improvement in all materials of instruction.

The situation became critical, however, when the obvious fact of individual differences was complicated by the doctrine known as the "constancy of the I.Q." Step by step, we were engulfed by an appalling determinism which fastened around the neck of each child a fixed "quotient" that went with him from the cradle to the grave. Under that plan, the pupil is no longer regarded as a living human soul and as possessing his own God-given personality. Instead, he is reduced to a *statistical* phantom whose "profile", a sort of mental fingerprint, is unalterably preserved in the steel files of the school, the catacombs of education.

Now, if this doctrine corresponded to reality, we should simply have to make the best of it. But serious doubts, based on much evidence to the contrary, have already begun to undermine this monstrous fatalism. When it is finally given up, as it will be, education will turn over a new leaf. A recent writer, Herbert McKay, has commented on these psychological aberrations with admirable candor and with caustic wit. To quote,

> "There is one set of averages that should be scrutinized with extreme care. Psychologists have a bad habit of expressing their results in mathematical form, and so giving them *a quite spurious appearance of exactness.** And when they average their 'mental quotients', applying a dubious arithmetical process to a mass of dubious results, one does not merely suspect the result.
>
> "Psychologists profess to measure general intelligence (having previously disclaimed a knowledge of what general intelligence is) by means of the answers to a number of rather absurd, and sometimes rather amusing, questions called 'intelligence tests' . . . . . . The arithmetic comes in in assessing the number of marks gained by the child and in dividing it by the possible number of marks—to as many figures as the conscience of the psychologist permits. *When the number of marks has been manipulated into an intelligence quotient it acquires an almost mystic significance.* We can proceed, with sufficient expenditure of time and energy, to find the average mental quotient for a whole school, or a whole city, or even for a whole country. *Arithmetic, what crimes are committed in thy name!* On the whole *it would be well to keep firmly in one's mind the exact origin of the psychologist's numbers and formulae, and to regard his averages with even more suspicion than usual.*
>
> "I once propounded the conundrum 'What is the average of Shakespeare and Lenin and Einstein?' My son replied instantly 'H. G. Wells'. But I have no doubt a psychologist would have given an intelligence test to all three, labelled each with a number, and found the average to two places of decimals."[13]

In the light of the foregoing discussion, what shall we say concerning the outcry about the "totally new program" which should be provided for "the other 85%?"

*Italics throughout by Mr. Betz.

First, it is obvious—statistically speaking—that 'the other 85%" actually comprise the vast majority of all "normal" pupils. Hence we should really ask, what is meant by a "normal" program for "normal" pupils?

Second, the idea of surrounding "the other 85%" with a halo, of describing them as the forgotten or neglected element of the school population, is thoroughly absurd. Most of these pupils are entirely "normal." They are *not* mental invalids. They are destined to form the bulk of our adult population. In their own interest, they should be handled firmly, precisely as Life will handle them. The war was a great revealer. It was truly amazing to see how many of our "chronic failures" and "problem cases" suddenly "found themselves" and measured up to inexorable requirements in the face of military necessity.

Third, mass education will always be a most complex problem. No miracle formula will ever change that fact. To blame all our troubles on the poor, unresisting "curriculum", the scapegoat and whipping boy of education, is neither honest nor helpful.

Fourth, the wholesale disability in mathematics, particularly in arithmetic, which the war emergency publicized so pitilessly, has been due, *not* to a curriculum which must be made more "palatable", but to factors which are known to every experienced teacher,—factors which we have been unwilling to bring out in the open and to correct.

Fifth, careful experiments in widely separated educational centers have proved conclusively that chronic disability in arithmetic, to the extent of involving whole grades or even schools, is entirely unnecessary and therefore unpardonable. When arithmetic is taught correctly, as a cumulative system, by trained teachers, and when all the teachers are expected to maintain a policy of firmness, such disabilities do not arise, or can largely be corrected quite promptly.

Sixth, the high school cannot build a satisfactory program unless the elementary school is willing to cooperate. The mathematical curriculum is incurably *cumulative*, and arithmetic is its indispensable foundation. *If weakness in arithmetic is tolerated by the elementary school, the high school finds it next to impossible to improve the pupil's status. Failure in arithmetic usually means failure all along the line.* After eight years of ineffectual pencil pushing in the lower grades, most pupils get tired even of "remedial lessons" at the upper levels. Who can blame them?

Seventh, the policy of evasion represented by the *postponement of arithmetic* greatly complicates the situation and virtually *prevents* the organization of a normal curriculum. It is an escape mechanism, grossly unfair to the pupil, that will not solve a single problem. No other country has even thought of such a course. There is not a shadow of doubt that American children *can* cope with a normal program in elementary mathematics, as do the children of all the other leading na-

tions. Running away from such a program by *postponing* it creates an unendurable handicap to pupils and teachers.

Life Situations and Experiences—Past, Present, and Future. What we have said previously about this matter must now be made more explicit for the purposes of the mathematical curriculum. It is a subject of vast dimensions, of which only a glimpse can be provided in a limited space. The following considerations, however, may serve to focus attention on the central problems:

First, the curriculum must maintain that close relationship between theory and practice which the whole history of mathematics so clearly suggests.

Second, the field of applications is too extensive to admit of "incidental" or "accidental" selections. For fruitful results, a careful plan of organization should be followed.

Third, at all levels of instruction, and especially in vocational and technical courses, the effective study of applied problems depends on an adequate mastery of the basic *mathematical* tools.[14]

Fourth, race experience—which is generalized experience—must be given preference over personal experience.

Fifth, the immediate, personal experiences of the pupils can and should be associated with generalized experiences by such devices as motivating classroom discussions, overviews, films, exhibits provided by the pupils, newspaper items of current interest, and the like.

Sixth, "future" experiences are necessarily theoretical, and should therefore be chosen with the utmost care.

Seventh, in selecting worthwhile "life situations and experiences," teachers should rely on dependable modes of evaluation. Among the most helpful criteria are those of *frequency of occurrence, universality,* and *permanent significance.*[15]

Organizing the Mathematical Program. We are now ready for our most crucial query. *How shall the mathematical program be organized?*

The thousands of curriculum pamphlets which have been issued in recent years, as well as a whole library of textbooks, have furnished all sorts of answers. But we have been unable to arrive at a generally endorsed solution. Numerous unsolved problems are troubling us as much as ever. We are still bound by the claims of our colonial compartment system. No other country attempts to teach either elementary algebra or demonstrative geometry in a single year. In England and in other leading countries, informal geometry receives continuous attention, beginning in the kindergarten. We are still refusing to acknowledge this subject as one of the necessary cornerstones of mathematics. No other country is *postponing* the essentials of a mathematical education.

The correction of this curricular anarchy presupposes: (1) a new *administrative* attitude which will permit the creation of a *continuous* mathematical program, and (2) a proper attention to *all three* of the essential components of functional competence in mathematics.

To repeat, an adequate mathematical program must do three things:

1. It must set forth, in convincing fashion, the *mathematical* ingredients that seem necessary.

2. It should indicate the most essential fields of *application.*

3. It must give due attention to the *learning process.*

A good beginning has been made in all three directions, but a proper synthesis has not yet been achieved. For years to come, our task will be that of examining with care all the building stones which are at our disposal for the new mathematical edifice, and of putting them together in the light of cooperative research.

Building Stones for the Emerging Curriculum. A detailed exposition of a tentative program such as we have suggested would require many pages. The documents to which we have referred contain excellent guiding principles that we should keep in mind. Thus, the Joint Commission Report offers a sequential organization of the basic mathematical categories, has a good deal to say about the learning process, and submits a helpful "analysis of mathematical needs" (Appendix I). The Harvard Report furnishes valuable comments along the same lines. Again, the Report entitled "Mathematics in General Education" supplies a wealth of information on the "major understandings growing out of mathematical experience."[16]

Perhaps the most urgent help which the schools should now receive pertains to the problem of "mathematical needs." The ten pages contributed to this subject by the Joint Commission Report should be studied with care. They present a discussion of such needs under three headings: "For ordinary life"; "For leadership and higher culture"; "For specialized use as a vocational tool." Elementary courses undoubtedly call for a simpler mode of relating mathematics to general "areas of living." In our concluding section we offer such a simplified version, in the hope that it may induce others to attempt more adequate formulations.

Mathematical Needs Related to Areas of Living and to Vocational Competence. The areas of living and of vocational competence specified below are not mutually exclusive. That is, the learner may be viewed as a future homemaker, as a citizen, as a worker, as a general reader, and so on. Hence, the suggested abilities and types of understanding and appreciation represent a composite training program which has potential significance for every pupil. We shall here consider five areas, with related abilities, which may serve as a provisional basis for the applied phases of the mathematical curriculum. Throughout, we are presupposing the training that should be within the province of the elementary grades, and are giving primary attention to the program of the secondary school, including grades 7 and 8.

1. The Mathematics of Personal and Home Life

This involves items such as the following:

1) Keeping a personal or family expense account.
2) Developing and using a satisfactory budget plan.
3) Saving at least 10% of one's income.
4) Opening and maintaining a savings account.
5) Learning about the services of a bank.
6) Knowing the meaning of a checking account; how to write and to endorse a check; and how to write a receipt.
7) Saving money by buying wisely.
8) Knowing about the advantages and possible dangers of installment buying.
9) Being informed about modern ways of buying and financing a home.
10) Knowing about other safe ways of investing money.

2. The Mathematics of Citizenship and of Social Security

Here we may include items such as the following:

1) Providing for personal security, and for that of one's family, through various forms of *insurance* (health, accident, unemployment, automobile, old age).
2) Having an understanding of the purposes and the machinery of *taxation* (local, state, federal), and providing for the prompt payment of all obligations arising in this way.
3) Being informed about, and contributing to, the agencies concerned with *public welfare* (Community Chest, Red Cross, Government loans).
4) Being informed about available modes of transportation and travel, of sending money and messages, and being able to compute expenses arising in this manner.

3. The Mathematics Necessary for Vocational Competence in Business, in Trades, and in Industrial Occupations

Under this heading we may list the following important items:

1) Having a mastery of numerical computations such as arise in business and in the shop.
2) Understanding and being able to use the ideas and processes of percentage.
3) Being able to use the common units of measure (English and metric).
4) Being familiar with the most common geometric forms, and with the basic geometric terms, ideas, and facts.
5) Being skilful in drawing or constructing the basic geometric figures.
6) Knowing the meaning of *measurement*, of degrees of precision and accuracy, and being able to use a graduated ruler as well as compasses, protractor, and squared paper.
7) Being able to make a scale drawing, and to read blueprints and maps.
8) Knowing how to use the idea of similarity for purposes of indirect measurement.
9) Knowing how to solve a right triangle with the aid of a table of trigonometric ratios.
10) Knowing and being able to use the standard *formulas* of business and of mensuration (percentage, interest, areas, volumes).
11) Knowing how to use *equations* in solving simple verbal problems (arithmetic, geometry, algebra, trigonometry).
12) Being able to use the Hypotenuse Rule, and to find square roots.
13) Being able to read, to interpret, and to make *statistical graphs*, as well as graphs of formulas.
14) Being sufficiently familiar with mathematical terms, ideas, and processes to be able to study basic vocational books and articles.

4. The Mathematics of General Information

In addition to the items mentioned above, everyday life calls for mathematical literacy along these lines:

1) Being familiar with the meaning and use of *basic mathematical terms* in everyday use, such as unit, ratio, average, percentage, proportion, rate, variable, constant, dependence, positive, negative, formula, dimension.
2) Being able to read and interpret very large or very small numbers (billions of dollars, millionths of an inch).
3) Being able to round off numbers.
4) Being able to compute averages based on given statistical data.
5) Being informed about the collection and use of public funds (for health, social security, civic improvements, protection, national defense and the like).
6) Being able to estimate numerical results in problem situations.
7) Being able to understand ordinary quantitative relationships, including the way in which a change in one quantity affects related quantities.

5. The Mathematics Necessary for Technical or Professional Competence

For all those who need more extensive training in preparation for scientific or technical pursuits, or for other professional careers, the Harvard Report suggests this broad rule: "All competent students with special interests in these fields should take all the secondary mathematics that is available." In general, this involves—as a minimum requirement—the satisfactory completion of good courses in algebra, demonstrative geometry, and trigonometry. These courses should be closely correlated and should furnish the widest possible opportunity for transfer by continuous emphasis on significant applications, on essential types of understanding and appreciation, and on generalized modes of thinking.

A Final Word. It remains to emphasize, once again, that the mathematical program of the average pupil—for that is what we mean by "the other 85%"—should not be defined in too restricted a manner. Only too often the current discussions of "functionalism" in education suggest pauperized curricula which are neither "liberal" nor "practical". Stripped of all verbiage, they seem to reduce elementary mathematics to an informational smattering revolving around a narrow range of "grocery store arithmetic" and a manipulative familiarity with a few standard formulas of measurement.

In this age of science, industry, and technology, not to mention the new era of global economy, this widespread reductionism must be considered both incredibly absurd and extremely dangerous. The conviction is

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Education in Science

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needs, and for each group they would vary according to major, contributory, or minor relationships within given units of instruction. For economy of energy and clarity of purpose and plan, it is necessary to determine what influences are and should be accepted as determinative of what is to be selected in these schools to meet these varied needs. A few of these determinants are suggested as illustrative of these varying interests of society.

1. Our freedom and independence were the dynamic ideas of our founding fathers, and we became a nation under the stimulation of a great idea. Immediately the demand for leaders made the establishment of schools a necessity, and, forthwith, schools were established as basic to the maintenance of the freedom and independence gained. We have promulgated the ideas of freedom and independence and have committed ourselves to a program of universal education as the basis of maintaining these ideas as a fundamental concern of our society. Men and women who have been engaged in the work of the sciences through the years have made a lasting contribution to the preservation of our freedom, and are a powerful force in the preservation of peace. The cooperative relationships with other curricular groups should assure us that the contributions of science will remain beneficient.

2. The pressures of one's country for expert services in relation to its progress is an evident influence for vocational and professional employment, directly and indirectly. These services can be learned by adolescents and are a part of the political and economic heritage for civic education. Science is potent for a changing pattern of civic life.

3. Certain emergencies of national and state-wide scope have been upon us frequently that could be resolved only through the aid of the workers in science areas: disease, floods, storms, accidents, fires; nutrition, food preservation, soil conservation, water supply, communication, transportation; instruments and tools, housing, specialized machinery; processing of plant and animals products, to name a few.

4. Standard of living has become to our people a sort of test of our prosperity. We say that our standard of living must be maintained in spite of war and emergencies. Without the aid of science we should make little headway to maintain the standard of living to which we have become accustomed.

5. Conservation of our natural resources—related closely to our standard of living—draws upon all sciences, whether in production, processing, distribution of products of field and forest, or in communication, transportation and processing. What a range of educational service appears at this item! It embraces land and mineral resources, water, wildlife, forests and all features of the universe that concern man's welfare. Conservation implies preservation but through wise use.

6. Occupations, vocations and professions, all pursuits of the people, constitute an inestimable source of content. Most of our people make their living in areas dependent either directly upon the use of science and its applications, or indirectly upon science contributions to changed and changing social patterns.

7. Cooperative and other types of economic organizations, social and religious institutions, language and literature, the arts and the disciplines, are all changing by the impingement of science facts and the issues that they raise.

8. Science has made us research-minded. Research in the sciences, implied in all of the above determinants, has given society not only the advantage of facts as such, but has provided a way whereby all may *discover for themselves* if they are so disposed. This calls for surveys and analyses.

The above influences and others which could be listed form a very important relational background for the general patterns of science in the various schools and classes. This leads to another aspect which has been implied throughout but must be made a little more explicit.

Interpretive Science. Education for the masses in secondary schools and classes, and in the technical institutes, must be defined so that the sciences may become selective and interpretive; that is, selective on the basis of a purpose in the sciences themselves, and interpretive on the basis of its application in some relational pursuit for which the sciences are to be utilized. Since there are scores of purposes for which science may have contributory value this is a very responsible task. Then, too, in a secondary school of adolescents, the science departments of colleges are concerned about recruits for these departments. They should have due regard for the selection of promising young men and women for advanced preparation in science at the college level. Since our emphasis here is for education in science for adolescents, interpretive science for one special area will serve to illustrate the adolescent need. We shall confine ourselves to education in agriculture as representative of rural education, and also as an area in which science is now inextricably related.

There are no modern textbooks in agricultural science that are adequate for adolescents. It is also difficult to find a textbook in science that deals with the issues of science, which would be satisfactory for high school students. No one teacher of agriculture, and no one teacher of science is competent to determine just what aspects of science have significance in an area as extensive as is agriculture. The teacher in agriculture might know what the science issue in agriculture is that he wishes to meet, but he is unable to select wisely and economically. The teacher of science, not knowing the issue, would tend not to select definitely enough to make the trouble worth while. Added to this difficulty is that of selecting and interpreting science according

to greatly varying local differences in agriculture resources and practices on the land. It is, however, important that the teacher of science in the secondary schools shall be well prepared, not only by well-rounded courses in the sciences but also by sufficient experience in rural areas, preferably on farms. He should be able to select and to interpret in this area. Or, if that is not possible because of the smallness of the school, the teacher of agriculture shall have had sufficient science to select and interpret on a competent basis.

Another alternative presents itself. In a school where there is at least one teacher of agriculture and one teacher of science, provided both are cooperative they may help each other. Some cooperation would always be expected. There is, however, loyalty to subject matter. The teacher of science will think of his problem as that of systematic science and the value of that for the student in agriculture. The teacher of agriculture desires that it be interpretive and directly related. There is hope in this relationship for the difficulty is clear, if the two teachers are interested. We need such cooperative situations.

Farming deals, as we have said, with many sciences, a large number of which are very significant: the growth of plants and animals with all that is implied in their nutrition, care, cultivation and management; the selection, management and utilization of soils for specific purposes of good husbandry; and the selection, servicing, and manipulation of machinery and equipment for the correct implementation of the farms—all reflecting the use of many sciences and technologies: agronomy, bacteriology, biology, botany, chemistry, entomology, geography, geology, genetics, mathematics, meteorology, nutrition, pathology, physics, physiology, and zoology. Interpretive science is more than merely scientific information, it is the understanding of a functional relationship in which the value of science is discovered, and in which the meaning of the science is enlarged. The student in agriculture gets help in meeting a difficulty, and the principle or principles of science are discovered.

Despite the fact that science teaching goes on generally by the use of textbooks and laboratory and other materials that provide a vast amount of knowledge, the adolescent develops motivation largely in problem-solving situations in life, without which science has serious handicaps. The orchardist who sprays his apple trees for control of pests and diseases, who chooses a system for pruning his trees, and then prunes accordingly, would become very much motivated to learn the value of science involved in sprays and spraying. For example, the importance of the pressure of the spray, the conditions of application, an understanding of the particular effects of the ingredients, or the requirements in pruning for growth of fruiting wood and for admission of sunlight and production of correct shape. The jobs cannot be done well without the science, and the science gets a richer meaning in its use.

*Francis J. DiVesta—*The Use of Interpretive Science in Vocational Agriculture*. Cornell University, Ithaca, New York. Contains many illustrations.

In a study* made under my direction, I find many of the relationships of the sciences depicted. A few of these, limited to the poultry enterprise, are given to show the extent to which science finds its way into agricultural enterprises: nutrients, their purpose and composition, the digestive system and how it works, assimilation, composition of feeds, composition of eggs; insulating values of various materials for ventilation of poultry houses, heat-loss factors, convection currents, drafts, condensation of moisture, moisture content of air expelled in respiration of various animals; in controlling and preventing diseases of poultry, the anatomy of the hen, methods of postmortem, appearance of diseased parts, effects of vaccine, purpose of blood test, effects of disinfectants of various kinds on parasites, bacteria and other micro-organisms; as to parasites, life history of internal and external, point of life cycle to give treatment, effects of various kinds of treatment; as to nutritional disorders, effects of vitamins, effects of lack of vitamins; as to protozoan diseases, definition, life history, types, methods of control; as to bacterial diseases, definition of bacteria, types, reproduction, cycles of important ones.

Among the few books that have dealt with the science of agriculture, there is one written on *The Physics of Agriculture* by F. H. King, 1901, from which Mr. DiVesta devised the following suggestive representation of relationships:

Chemical combinations in soils. (Soil chemistry)
Influence of rock texture on soils..... (Geology)
Formation of humus soils........... (Geology)
Formation of glacial soils........... (Geology)
Wind formed soils.................. (Geology)
Soil convection........... (Physics, Agronomy)
Essential constituents of fertile soils.........
.... (Soil chemistry)
Functions of essential plant foods..........
.... (Plant physiology)
Chemical differences in soil types.............
.... (Soil chemistry)
Amounts of foods removed by plants.........
.... (Soil chemistry, botany)
Nitrogen cycle........... (Botany, Bacteriology, Plant physiology, Chemistry, Agronomy)
Textures of soils......... (Agronomy, Geology)
Pore space in soils............... (Agronomy)
Air movements........... (Agronomy, Physics)
Gravitational water................. (Physics)
Capillarity in soils.................. (Physics)
Hygroscopic water.................. (Physics)
Respiratory organs in plants. (Plant physiology)
Function of plant roots in gathering moisture)
.... (Plant physiology)
Needs for free oxygen in the soil...........
.... (Chemistry, Botany, Bacteriology)
Conditions influencing soil temperature......
.... (Agronomy, Physics)

This indicates the attention given to the relationships between science and agriculture. A present day treatise would indicate many more connections which the research of the past 50 years has made significant. Attention is directed to the Annual Reports of the United States Department of Agriculture for such contributions.

Organization of the Curriculum. In the organization of curricula and courses of study, many differences of opinion are reflected. It is not difficult, however, to reduce these to indicate two approaches: (1) *the logical,* which emphasizes the subject-matter point of view, and its gradation according to a systematic plan which the facts of science suggest; and (2) *the psychological,* which emphasizes the adaptations of science to the issues of life, to the solution of which it makes its contribution. Both points of view are essential. The former is more appropriate to the more mature student, the student in college and advanced in the curriculum; the latter is more appropriate to the less mature student, the student in high school, unless there are exceptions made for selected students who may desire specific general courses for college entrance.

Since we are thinking primarily of adolescents, the organization of science curricula and courses for particular groups should have regard for the wide diversity of the science during the student's earlier years, and should adjust accordingly. It should have regard: (1) for the learner, his experience, his purpose, abilities and maturity; (2) for available local materials of instruction found in natural settings within the community of the school; and (3) for the types of science positions found within the area of the school, whether in teaching, research, or in pursuits. Unless such adjustment is made in curricula and courses to meet this diversity of interests and education, other arrangements should be made administratively for transportation of students to other school centers where interests may be met. To do this the enlargement of certain school administrative units may be necessary in appropriate centers.

The Cross-section Type of Arrangement of a Curriculum. The cross-section arrangement of the content of instruction is a practical harmonization of the logical and psychological approaches. Where there is a logical arrangement, information is presented with the main emphasis upon subject matter, and examinations in subject matter take precedence ordinarily over other types of evaluation and measurement of results. Where there is a psychological arrangement, though the subject matter may be similar, it is contributory to common-life or career motives, and to the purposes of life in which the science became formulated. In this approach the experiences and abilities of the learners and their competencies in performance would be regarded as of paramount importance. This arrangement does not deny to science any of its relative values, whatever major sequence the student chooses to follow through the high school, the technical institute, or the junior college: English, foreign language, social studies, mathematics, vocations, health and hygiene, physical education, or whatever.

The curricula and courses of study would be laid out on the basis of major sequences, following a logical procedure through to the end of the curriculum, but also on the basis of psychological symmetry, or integration, that is, on the basis of relationships of total courses taken. Participation in natural settings within the area of the school would provide the necessary experience within which whatever subject matter chosen would gain appropriateness and balance. With a science major, this would mean that all other subjects taken would contribute directly and indirectly to the science major sequence. Intimacy of relationship of purpose and content would determine the relative values of the other studies taken as minor sequences in the total curriculum or course.

This principle of relationship would follow in the course of study and in the units of instruction. Assuming that the student intended to continue into the technical institute or the junior college, even into the senior college with a science major, the quantity of science in terms of credit per term or semester would increase and earlier contributory and minor subjects would advance too if needed, but on the whole would decrease or be replaced by other contributory studies. This would mean specialization in science. If, however, science were represented as a minor to vocational agriculture, the major sequence, its content and organization would minister to farming as suggested above. School curricula, courses of study and units of instruction organized on this basis, though presenting some minor difficulties of administration in small high schools, would meet the needs of students in rural areas and provide the appropriate education for terminal students, for preparatory students for college, and for general education for local graduates. This meets the demand of a rural secondary high school, and is a community school.

Teaching Units. The procedures followed in selecting specific science content for units of instruction are markedly similar to the procedures of making courses of study, curricula, and community programs. They are controlled by adaptations to the maturity of the potential learners, by emphasis given to the idea, issue, or pursuit under consideration, by utilizing the local facilities for the teaching of the unit, and, of course, by planning within the range of the learner's comprehension. Teaching never goes better than in a situation where there is an appeal to creativeness in the learner.

As illustrative of a very interesting unit of instruction which it was my pleasure to teach to secondary students in agriculture, permit me to describe in skeleton fashion what the unit was and how it showed the connections of science and agriculture. The purpose within the course of study of which this particular unit was an integral part came under the following caption: "How to protect the corn plant against insect pests and plant diseases." The *particular unit* was limited to: "How to protect the corn plant against the corn borer." Since the unit was regarded as of particular importance, two periods of 90 minutes each were given to the total teaching act. This was a highly motivated unit, since at the time the United States Government was provid-

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NEW BOOKS

Doorways to Science

• *By* GEORGE W. HUNTER and WALTER G. WHITMAN. New York: American Book Company. 1947. Pp. XIII + 546. $2.40.

This is the most attractive recent text in beginning science that the reviewer has examined. It is an example of good bookmaking. It should enjoy a wide and lasting popularity, for it will sell itself on sight. The book is scientifically and pedagogically sound. It is written in a simple, interesting style, employing a vocabulary suited to junior high school students.

The book contains a special section devoted to scientific hobbies in addition to twelve well chosen units, each of which is subdivided in from three to seven problems or chapters. Each problem contains a group of topics for class discussion, a quiz, and a list of new terms. The units are followed by 2—6-page reviews which include such subdivisions as things to remember, tests on fundamental concepts, and student activities. The illustrations, which include photographs, line drawings, and graphs are outstanding, adding much to the attractiveness of the text. *H.C.M.*

Laboratory Manual of General Biology

• *By* E. GRACE WHITE, Ph.D. Third Edition. St. Louis: The C. V. Mosby Co. 1946. Pp. 278, loose leaf. $2.00.

This manual is designed for use with the author's text, and follows it closely. There is material enough for at least three semesters' work; some exercises can be omitted without disturbing the general plan. There is an excellent set of instructions for doing laboratory work in general, and for using the microscope. Directions for dissection are good. There are some misprints, "Ascaria" for "Ascaris" on p. 160, for example. As in the text, the references are not always to the most recent editions. More types are described than can be covered in the average botany or zoology course. There are a large number of questions which aid the student in understanding the specimens. *T.D.H.*

General Biology

• *By* E. GRACE WHITE, Ph.D. Third Edition. St. Louis: The C. V. Mosby Co. 1946. Pp. 659. $4.50.

This book is divided into three parts: The Unity of Life, Problems of Biology, and Progressive Organization, the latter being subdivided into Plant Kingdom and Animal Kingdom. The grasshopper is described as a typical animal; this is followed by a brief discussion of protoplasm and the cell, and animal mitosis. The general anatomy and physiology of seed plants are then discussed. One-celled organisms are taken up next; Paramoecium is described as a type, and others, including the bacteria, are discussed briefly. The author is emphatic in accepting the interpretation that Paramoecium undergoes degeneration unless conjugation or endomixis intervenes. Most workers do not accept this interpretation, at least in regard to all species of Paramoecium. In this connection there seems to be no reference to work done later than 1926.

The second part begins with a description of basic chemistry and physics, followed bv a discussion of metabolism from the chemical point of view. The amount of organic chemistry given might be confusing to the average beginning student. This is followed by a description of meiosis, inheritance, and a brief history of biology in which there is some discussion of evolution and recent developments in inheritance.

The third part includes a large number of plant and animal types, most of them being discussed very briefly. Each section includes an outline of classification. Then comes a consideration of animal adaptations, including the evolution of the horse as an adaptation for running. There is a fairly large glossary and a list of references. The latter does not include certain recent publications. Dahlgren's *Production of Light by Animals* (1926) is included but Harvey's *Living Light* (1940) is not. In several cases, such as Pool's *Flowers and Flowering Plants* (1929 instead of 1941), the most recent editions are not mentioned.

In several places the order might be questioned. Evolution is first discussed in the second part and again at the end of the book; and inheritance is discussed in two places in the second part. A number of errors and misleading statements are to be found. Mendel's results were published in 1866, not in 1863 (p. 321); the statement on p. 264 "in 1900, when the publications of the monastery were made public" is misleading, since they had already been published; on p. 595, in the classification of animals, the Vertebrata are omitted; the statement on p. 294, "In the animal polar bodies are formed and discarded during the development of the egg; in the plant all the egg cells contribute to the formation of gametophyte tissues" is inaccurate since the gametophyte generation is never described as being formed from eggs; the statement on p. 329, "In the group of plants known as Thallophytes the plant is a gametophyte. The spore is formed within a thick-walled zygote and no sporophyte is formed" applies only to a small number of Thallophytes.

Such errors are perhaps due to an attempt to cover too much in too small a volume. This means that many topics have to be mentioned and not followed up, and that the author has been unable to check carefully on all statements. On the whole, the book would seem to be suitable for only certain biology courses. *T.D.H.*

A Textbook of Qualitative Analysis

• *By* WILLIAM BUELL MELDRUM (Haverford College) and ALBERT FREDERICK DAGGETT (University of New Hampshire). New York. American Book Company. 1946. xi + 431 pp. $3.50.

At one time qualitative analysis occupied an honored and secure position in the scheme of chemical education. Solubilities, colors of compounds, schemes of analysis, were fundamental to the descriptive chemistry then taught. But with the increased knowledge of theoretical chemistry, during the past twenty years the instruction in qualitative analysis has been examined critically and two stubborn facts have emerged: 1. Practically no one carries out an analysis by the traditional methods because easier and faster methods, such as spectrographic analysis, are available; 2. Even if one wanted to carry out a qualitative analysis of such a relatively simple material as a steel by these methods, complications introduced by the presence of interfering substances, such as tungsten, molybdenum, etc., make the simple schemes entirely inapplicable.

The reaction to these facts has been of two sorts. One group, deciding that qualitative analysis has no considerable value in the modern scheme of instruction has either eliminated it entirely or has relegated it to a minor position in connection with the usual inorganic course. The second group has changed the content of the course, minimizing the descriptive material and emphasizing the theoretical background; to this group qualitative analysis has become a vehicle on which to carry a great load of elementary physical chemistry.

The general nature of this book is indicated by stating that it is designed for this second group—the theoretical section is approximately twice as long as the descriptive section. Its intended purpose it serves very well indeed. The theoretical section contains extensive discussions of atomic and molecular structure, reaction kinetics, ionization and other equilibria, electrochemistry, and colloidal phenomena. The discussions are accurate and much more extensive than those usually found in books of this type.

The descriptive section and the schemes of analysis contain a few unusual features. The sodium sulfide separation is used for group II-B; the separation of group III is quite different from that usually employed; the grouping of the anions is, to the reviewer's knowledge, original; the use of chloroacetic acid to adjust the acidity in groups III and IV is relatively new. It is, unfortunately, impossible to evaluate the effectiveness of innovations by reading descriptions of them.

A definite attempt has been made in the descriptive section to interpret the procedures in terms of the theoretical discussion, but the reviewer feels that, in this as in all other books, much still remains to be done if both parts of the work are to have their maximum value. Since, however, the book is an all-out effort to emphasize the theoretical background of analytical procedures—a campaign with which the reviewer is in complete accord—he welcomes its appearance, with very few reservations.

T.H.D.

The Principal Talks

(Continued from Page 46)

A second thing he will note is the relation between blackboard space and the size of his classes. He will make up his mind, while he has leisure to think carefully, into how many board sections he must divide the class, and how each section can be routed to and from the boards so that passing in the aisles may be avoided. When the first group is sent to the boards, whether the first day or later, the routing is directed, plus the statement: "Please go in this order always to avoid confusion." The beginner will find that sending definite sections in turn, instead of selecting individuals each time, saves many minutes, and distributes board practise more fairly. He will prevent much confusion if he allots one slate to each pupil in a section. If he realizes the importance of "setting up" his class room exactly as he "sets up lab", he will see that one eraser and one stick of crayon are placed in the center of each slate, and say to the first group, "Stand in front of the eraser."

There is another teaching possibility offered by that first board work, no matter when it occurs.

"Look at your slate as if it were your sheet of paper. Point to the place where you would write your name. Draw a straight horizontal line to represent it. Make up your mind how wide a margin you should allow. Point to the place to which your first word should be indented. Suppose you were to write a three line paragraph. Draw a line to show the first line of the paragraph. Did you indent it? Draw the second line—the third. Step back a little and check the appearance of your general arrangement. Use your eraser to correct your margin if necessary. We indent our paragraphs and keep even left hand margins at the board, exactly as we do on paper. Remember to do this every time.—Erase." *Now, repeat that drill immediately.* This will usually fix these points for all time in most classes. With a very slow class you may have to do this every time they go to the boards for the first few days.

Regimentation? Certainly! Exactly the same kind that we use in teaching good table manners, or anything else that needs to be made a matter of routine, and for exactly the same reason. There is such a thing as efficient management. It selects certain actions or activities that must of necessity be repeated often, and makes the right way automatic. How do you know this method is the right way? *You don't*, but you can be sure that *any* good method is better than none at all. Liberty does not mean absence of direction, and class room confusion. We can be business-like without being dictatorial. A knowledge of good form, and the habit of using it, is a valuable asset. Your own class and test papers will show the effect, and the English department will bless you, but getting the habit of good form is the job of every teacher, not of the English department alone.

Another thing to be decided upon while you still have leisure is your "Clean up" policy. The beginner often does not learn until it is too late that, with the exception of his supervisor, the janitor is the school official with whom it is most important that he be on good terms. If you leave your room with windows closed, shades drawn evenly, boards tidy, crayon and erasers cared for, floor cleared of papers, and seats raised for easier sweeping if this is possible, the janitor will sing your praises, which will do you no harm. How long will it take? If, when you say "Clean up", that means that the pupil nearest each window closes it and arranges the shade, the one nearest each black board slate takes it as his special job, every one picks up papers and raises his seat when he stands, the time used will run from 15 to 30 seconds daily. Results? A trim, tidy, well-ordered appearing room, which will be duly noted by your supervisor, the janitor, and the student body as well.

But, you say, none of these things have anything to do with teaching. No, but they are the things that make teaching possible. If they are not prepared for before you try teaching, you will find rough roads ahead. You must, of course, plan your teaching of subject matter as well—enough so you can work with your class, without texts and with little material except your crayon and blackboard, *for an entire week if necessary.*

When I say "lesson plan" that does not mean the beautifully executed document you handed in once or twice in methods class. You learned the theory in that plan, and made a carefully outlined exhibit. Now you must learn to make practical—not necessarily beautiful—plans for everyday use, and do it rapidly. You will have to make a minimum of 200 plans a year if you have only one subject preparation a day. This will range upward to six or eight hundred if you teach several subjects. Your plans may be pencilled or penned, or typed if you are able, in any form you prefer *so long as they name for you in consecutive order exactly the moves you are going to make in your class period.* These plans are the road maps you follow to your destination. They are simply memoranda of the procedures you have outlined for yourself.

They will list in some definite place—a separate sheet if necessary—the materials you need to have at hand for any lesson; the diagrams, sketches, lists and the like to be placed on the board before the class meets; and, most important of all, the steps in consecutive order that you will need to take in developing that lesson. If there is a fact test to be dictated or placed upon the board, the questions and also the answers, for economy of time in correction, should be at hand. In addition to your lesson technique, things that the beginner finds he is apt to forget, such as "Check roll; assign next lesson; check and collect home work; clean floor," should be included.

There is a certain amount of "candy" in any course. Offer some of it first. *Sell* your students on your course exactly as you would sell their fathers on a business proposition. Make them want it. While you need to take first things first, and easy things before difficult ones, you do not have to begin with the first lesson in your

book nor the first experiment in your syllabus, provided you find something that ties in better with your first day. It really does not matter much *what* you teach that first day if you *do* teach, and leave with your students the conviction that they have learned. I have seen the same course opened successfully by a dozen different teachers in a dozen different ways.

I remember one teacher of general science who asked her students how many thought it was bad luck to break a mirror, and why. She ended with a wide awake class, plus a vocabulary list on the board built up during the discussion: science—superstition—scientific attitude—experiment—check or control—guess—theory—fact—conclusion. I saw another teacher start the same course by asking what happened when you let a horse hair lie undisturbed for several weeks in a rain barrel. Her class plan followed much the same pattern, and reached nearly the same end.

I have seen a first day biology class open with a teacher's desk loaded with mason jars, in each of which swam a minnow. After preliminary discussion, which developed the fact that scientists observe before they draw conclusions, each student was given a jar, and asked to study and then to sketch what he saw. That same teacher once opened a general science course by telling the story of some ancient philosophers, who argued long and loud over why a full jar of water did not overflow when a small fish was dropped in carefully. Then she stopped and asked the class with a perfectly straight face, "What do you think the reason was?"

After they had sufficiently sold themselves by their suggestions, she added, "Now, I'll have to finish that story. Finally, one smart fellow dropped in a fish and the jar did overflow. Compared to the other philosophers, this man was a scientist. Why do I say so?—He experimented—He tried it. He had a scientific attitude. What does that mean?—Did you show an attitude of that kind a few minutes ago?" Her lesson finally developed much the same vocabulary list and the same ideas of the lessons mentioned previously, but she also covered terms like biology; geology; zoology; physiology; psychology.

I have seen a general science teacher start with a quart of milk and a quart of water, and ask students to say which was the heavier. "How many of you will stay an hour tonight if your answer is not right?" Only one! "How do you know? Did you guess? Gamble? Or have you experimented?" That lesson demonstrated terms like experiment, air, procedure, conclusion, and scientific attitude, and sent away a lively class which would be wide awake again tomorrow.

Simple demonstrations of fundamental principles, even with note taking required, are apt to interest a beginning class keenly. With beginners in general science courses, learning to recognize, name, (and incidentally to spell the names of new and unfamiliar apparatus), —test tube, Bunsen burner, ring stand, water bath, delivery tube, bell jar and the like—offers a brisk two or three minute class opener every day for a week, which may be extended to include a two minute practise in rapid sketching of these at the board. The spelling of the names of any chemicals used should be learned, and a vocabulary list may be begun for the class note books. As it lengthens, that list alone silently convinces the student that he is really learning something.

In addition to his first day's plan, the new teacher should outline enough work to enable him to keep a class profitably busy for an entire week, with textbooks lacking. He may not need to use this material now, but he will be ready if he has to. It is the part of common sense to plan these lessons so that reference to the basic text will reinforce them when texts are available. Some of the numerous things the beginner learns by an early visit to his prospective school are what his basic texts are, what reference material is on hand, what apparatus is ready for use, and what more is needed. Any lacking material or apparatus should be placed on requisition at once, instead of at the last minute. The beginner must remember that it is useless to spend time in planning a lesson or experiment if, when the time comes to present it, the material to set it up is lacking. If you have not and cannot get the material, you will have to substitute another project. Now is the time to find out. It is imperative that you make your lesson plans fit as well as possible the texts and the apparatus you will have to use.

A final word to the beginning teacher: You will find some marked similarity between class room teaching and any work you have done in public speaking. Many of the same principles apply. You must have a live approach in both cases. You need to pick up your audience with your eyes before beginning. You must train yourself to see your whole class instead of the person reciting. You should make a point of selecting several auditors in different parts of the room, and change the direction of your gaze frequently. If you speak in a tone to be heard clearly in the rear of the room, you will hit everything closer in. And finally you must know what you are going to say—you must have command of your material. Remember that it does not matter so much *what* you are trying to teach that first day. The important thing is that you do have something to get across. Having it ready is the thing that will give you self-confidence. If you say to yourself, "I have analyzed this; I can do it," *you can.* ●

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"A classic example, however, of what happens when existing literature is not thoroughly canvassed is found in the loss of more than a generation of progress in the field of genetics when Mendel's rules governing hybrids did not come to the attention of other scientists working on heredity. Because of inadequate library facilities in Mendel's time, published research was dead and buried unless it received immediate attention."

HARRY C. BAUER
The Educational Record
October, 1946.

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Education in Science

(Continued from Page 58)

ing placards, pamphlets and bulletins, and had appropriated considerable money for the fight to exterminate, or at least control, the European corn borer. Considerable curiosity was aroused. A chart about 20 by 30 inches was placed on the wall, the borer, in *red*, suggesting an ominous situation. Both agriculture and science could cooperate on this problem. It was an animal organism capable of doing great damage to a plant of large economic importance. What is the European corn borer? What does it do to the corn plant? What shall we do about it?

Since two 90-minute periods were to be used for general and special assignments for instruction, the direction and supervision of study, the discussions and other class activities in presenting the ideas discovered, and the culmination finally into prepared generalizations for exterminating or controlling, a time schedule was determined for accomplishing the various parts of the unit within the 180 minutes. The assignment was a lively give-and-take between the class and the teacher. This gave opportunity for grasping what was to be done and for utilizing any special experiences and items of knowledge already available in the group.

As I recall the unit of instruction, in brief it resolved itself into four pivotal questions which they prepared to study:

1. What damage do corn borers do? A study of the problem as it relates to the growing plant, the nature of the damage, and a judgment of the organism by the nature of damage.

2. What is the nature of the European corn borer? A study of the nature of the organism, its characteristics, how it reproduces, the life cycle, how it migrates, and what are its hosts.

3. What economic losses were incurred? A study of losses for particular fields in different states in terms of production yields and economic values.

4. What can be done to control the organism? A study of the means used for control such as types of plows and materials, when and how to plow, using results of experimentation with sprays and other controls, and making general use of what was learned in factors one and two above.

It is evident from the above outline how science would contribute to the content of a unit such as this. It provides opportunities for the applications of science in several very specific directions and assists farmers also in the promotion of corn growing. In the same general way science applies to the area of home economics, industrial education, the arts, in fact in all subjects within a course of curriculum.

Teacher Education. The teacher is an all-important factor in determining what to teach. The present shortage of teachers available and the inadequacy of persons in training are embarrassing problems. In very large numbers graduates of colleges, prepared to teach, have been attracted in other employment directions by much larger salaries than schools are able to pay. This is especially true in positions where the teacher preparation has great "carry over" values. Currently, one of the biggest difficulties of school administration in science education is to recruit and retain competent individuals for teaching posts, since the demand is so great in other types of science application. The college group must, however, for self protection, not only assist in determining what science particular groups of students need for general and specific competence in science at the different age-groups for entrance into college, but also what science the adolescent needs, who enters practical pursuits and begins the art of making a living and a life at the end of the high-school period or even before completing a secondary school curriculum.

IV. Summarizing Statement

This is not intended to be a complete summary of the issues which have been raised in this discussion, but the more important points are repeated here for emphasis:

1. Science is concerned with systematic knowledge based primarily on a cause-and-effect relationship; it is an integral part of the total understandings of the several branches of science that affect the various cultural patterns of human society; and it seeks to establish a scientific method, or methods, for the discovery of facts and for the evaluation of these facts for human living.

2. Science seeks to accumulate an accurate body of knowledge which would constitute valid educational resources for the extension of instruction, organized for general use by the public whose scope of general education is widening.

3. Science is very significant for study at the adolescent period of growth, since it is a period of plasticity and flexibility and represents the optimum time for reaction to the offerings of education, partly because of the large number of persons involved and partly because of the possibility of available and abundant physical energy.

4. Since science is an integral part of all education it is committed to the acceptable aims and objectives of education: (1) the promotion of growth and development as far as is practicable; (2) the provision of opportunities for the development of right social attitudes through family, play and recreation groups, and other informal activities; (3) studies of the social order, its groups and their constitution, government, and the like, to provide for participation in these; and (4) the maintenance of opportunities for acquiring competence in economic and vocational modes of industrial and business pursuits, including the related contributory knowledge available and necessary for a progressive economic order.

5. The abilities which science finds essential should be selected as basic to a program of science education. There are many types of abilities; among these, for exploration and orientation, for skillfulness, for socialization and democratization, for vocational competency, for standards of excellence through discrimination.

6. Science must recognize certain determining influences of the total society, of the community embraced by the school including its pursuits, of the school and other educational agencies, general and local, such as are significant for the selection of what to teach in science courses.

7. Education in science for the masses must be selective and interpretive of the most likely issues of life, and must focus attention upon content. This determines the selection of textbooks, bulletins, and other oral and printed materials.

8. Science must regard the areas of practical application, not only as a science service, but also as a means of the development of science itself, hence the importance of the applications of science for discovering new problems and the gaining of new meanings for science.

9. The importance of setting up problem-situations in natural settings can hardly be over emphasized for promoting instructional outcomes. This type of instruction involves careful supervision but it pays.

10. The curriculum should be organized on a psychological basis for maximum learning since genuine learning begins that way.

11. Teaching units in science are organized as integral parts of a course of study which in turn is an integral part of a curriculum, or they may be parts of a related course of study or curriculum such as a part of the poultry course and of the agriculture curriculum. Within the course of study, they are determined largely by the purpose of the course of study and local needs, and also by the more general purpose of the curriculum.

12. Teacher education in science is a fundamental responsibility of teachers of science and teachers of education, in cooperation with teacher education departments and schools of education. Educational and vocational guidance and counseling are important phases of this preparation. ●

The Future in Physics

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the talented young men will be able to pursue their studies, and still fewer will be available for industry. Moreover, the physicist will need to know more and more about hitherto unrelated fields, biology, medicine, politics, etc. His quiet and secluded life has been replaced by a fevered round of activity, talks on scientific subjects before the general public, overcrowded class rooms, scientific advice on matters of state, and many other things. His sphere of activity has suddenly broken out of the quiet laboratory of the past.

The future may be inferred only dimly, but it promises to be most exciting. We can be sure there will be kaleidoscopic changes with one new discovery following closely on another. Surely there will result a better understanding of the world in which we live. We can but hope that the new knowledge will be so used that we will be able to look with pride on the achievements of physics in the future. ●

Rubber—Natural, Synthetic

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So we find that in 1915 the nation consumed, for the first time, 100,000 long tons of natural rubber in a single year. That was five times the amount used in 1900, and more than 25 times that turned into products a half-century before. This, as all know, was but the beginning of the rise of the automotive industry toward its present stature, and 15 years later, in 1930, the nation's rubber plants made 375,000 long tons into goods. Such expansion was phenomenal, but it was to be dwarfed by later achievements; for in 1940, the last pre-war year, and despite the fact that the nation's most severe depression had occurred in the preceding decade, 650,000 long tons were consumed. All but a tiny percentage of this was natural rubber, and its supply had been made possible by the plantation developments in the Far East, mentioned earlier.

War interrupted crude rubber imports in 1942, and the feverish struggle began to get our synthetic rubber plants into the tremendous volume needed to sustain our military effort and a civilian life that literally depended upon automotive wheels. Production of all types of rubber articles except those needed by the armed services were drastically curtailed and their use rationed and regulated. The rubber industry functioned by drawing sparingly on the reserves of natural rubber built in anticipation of this national emergency, and the small supplies of synthetic material from some privately owned plants. Before we had finished the task of getting enough synthetic rubber capacity to meet our needs, in 1943, the nation had expended more than 700 billion dollars in the creation of 51 separate plants, the operation of which involved 49 rubber, chemical, petroleum, and industrial companies. These plants included all producing the raw materials and those which converted them into synthetic crude rubber. To speed the program, uniform methods of producing the rubber were introduced after the chemical and engineering specialists who aided the government in carrying out its program had been consulted.

During all 1941, a total of only 8,383 long tons of synthetic rubbers were produced in the United States, all from privately owned establishments, which under the lash of war increased their production in 1942 to 22,434 long tons. The government plants got into production in 1943, and that year from both governmental and private sources, 231,722 tons of synthetic rubbers came. The following year, production was 762,630 tons, and for 1945 a total of 820,373 long tons, the peak. Estimated production of 1946 was 730,000 tons.

Meanwhile, imports of natural crude into the United States, which never had been completely cut off, due to sources in Africa, Ceylon, India, South America and of guayule from Mexico, began to rise again even before conclusion of the armed struggle, and in 1944 totalled 98,169 long tons as compared to 34,514 in the year before. For 1945 they were 128,929 long tons, and for

1946 the estimate is 400,000 tons. Forecast for 1947 is approximately 500,000 long tons out of a total of 1,200,000 produced for all the world.

With the plantations and other sources pouring a flood of natural rubber onto the world market, and with the synthetic rubber facilities of the United States alone capable of producing approximately a million tons of man-made rubbers annually, the question naturally arises as to what sphere each will occupy. This concerns only the general-purpose American types as contrasted with the natural, for the specialty rubbers, with properties that make them economically practical even when their price is higher than the natural, will continue to retain and expand in applications where they serve best. It has been recommended by many leaders in the government and in the rubber industry that a portion of the synthetic facilities capable of producing a minimum of 200,000 to 250,000 tons a year be maintained as standby protection against any other national emergency, and that research be continued and intensified to make this type synthetic the equal if not the superior of the natural. This rubber, it is contended, should then be used in conjunction with natural. For the remainder of the potential production it is recommended that it go into direct competition with the natural on a price basis, so that each will find its true economic level. Proposals on this are now before the Congress of the United States for their final decision. ●

Projects for Science Students

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almost of the nature of research problems, and reasonable skill on the part of both the boy and the instructor is required. For instance, one student has designed and is building a small refrigerator which works on the principle of the gas flame refrigerator. Another is studying the properties of sand when subjected to rapid and strong vibration, to see if it acts like a liquid and shows signs of surface tension, capillarity, and viscosity. Still another is measuring the diffraction effects produced by the lenses of his high grade miniature camera in an effort to predict the ability of the lenses to do special photographic jobs. In past years, boys have designed and built a modern Cavendish experiment for finding the gravitational constant. This has been done with great accuracy. The Rowland experiment, demonstrating that a moving charge has a magnetic field associated with it, has also been performed. Now and then a boy becomes interested in spectrum analysis and learns the correct use of prism or grating spectrometers. Polarized light is being used to study the stress patterns of a miniature plastic girder for use in model airplanes. And so it goes.

These projects are not always completed. Sometimes a boy tackles more than he can reasonably be expected to accomplish, either because of lack of time or because of lack of equipment and experience. However, in either case he learns that nature is not as simple as the regular courses seem to indicate and that, in the words of G. H. Parker, "In spite of the most carefully controlled laboratory conditions, Nature does just as she pleases." The student learns to sit back when in difficulty and think out alternative methods of solving his problem; he learns a bit more of the problems of accuracy and error, and he learns to respect the men who pioneered in scientific discoveries.

Keeping a good boy going demands patience and understanding on the part of a teacher. He must learn not to discourage an unusual idea unless absolutely sure that it is unsound. Young minds, lacking in background, often combine facts in unusual but possible ways. Most of the revolutionary ideas of modern physics have been formulated by relatively young men, such as Heisenberg or Einstein.

It has been our experience in talking with these boys several years after graduation, that their pleasantest memories of the school are the hours they spent in the laboratory working on a problem. Moreover, it is not uncommon to find that work on a project gives a boy a lasting scientific interest. And it is probably no mere coincidence that the majority of our students who pursue scientific research through college are those who worked on a project when they were students in this Academy. ●

The Place of Science

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eral education. On the elementary level, from grade one to grade six inclusive, the science course is usually called nature study, and takes the form of stories about nature and man's relationship to his environment. For the most part these stories are selected because they are interesting. Many of them have no particular significance for a better understanding of the place science has in modern living. The stories cover a wide range of scientific thought, apparently attempting to give as many facts as possible. Perhaps it would be better to tell a variety of stories about a few fundamental scientific facts, rather than stories about many varied facts.

The story-telling technique also misses a most important objective of the science course, in that it does not aid the development of skill in scientific thinking. Perhaps the greatest contribution of science has been the development of a new method of thinking, based on observed facts and experimentation. It is the scientific method of approaching truth and forming judgments that needs to receive added emphasis in general education, rather than the accumulation of scientific facts in specialized fields. Science teaching in the elementary grades should lead children to observe facts carefully, to experiment, and to weigh all opinions before making judgments. In other words, the pupils should learn to avoid snap judgments and opinions based on prejudice. Such teaching would carry over into many other fields. It would make us a people less susceptible to demagogues, spellbinders, flag-wavers, and high pressure advertising. It would motivate us to resist the psychologically deadening influences of motion picture and radio propaganda. Nature study need not neglect teaching some basic laws of biology, chemistry and physics. The knowledge of such laws and facts is important, but the development of the scientific method of thinking is far more important.

On the junior and senior high school level, a criticism of the science offerings arises from the fact that the courses of study and the textbooks are products of college trained men who are specialists in these fields. Consequently most high school science courses are not adequate for general education. The student who enters the physics class in high school takes a course which is specifically designed as preparation for the further study of physics in college. The textbook he uses is written by a physicist. His teacher has specialized in physics on the college level, and the whole approach to the subject leans more toward specialization than to generalization. Yet this student may have no intention of ever entering college. What he learns does not have enough significance for an understanding of the entire field of physics, because it assumes further study of the subject later on. The teacher is forever saying, "You will understand this better when you get to college." The result is that the student who does not go to college never understands it completely. Neither does the material have great significance for adult use to anyone who does not become a physicist or an engineer. There is ample material in the field of physics that touches upon ordinary living. The housewife, the businessman, the attorney and the clergyman are constantly contacting the facts and laws of physics in their ordinary every day living, but somehow or other these are never included in the high school course. The implication is that they are not respectable material for study. Yet they do constitute part of the field of physics, and could be used to develop a total appreciation of the science while developing the habit of scientific thinking about ordinary things. Perhaps the courses of study in scientific subjects for general education should be built around questions that housewives, attorneys, salesmen and bank clerks might ask, rather than upon what engineers and laboratory technicians know about these fields.

The objection will be raised immediately that such courses would be too easy for the brighter students, or inadequate for those intending to go to college. In the first place they need not be made easy because they deal with ordinary daily experiences, and there is no reason why special courses could not be given to those preparing for college. It is well to recall here that twenty-five years ago the majority of high school students went to college. Today eighty per cent of high school students never attend college. The high school, which formerly was in fact a college preparatory institution, is now a terminal educational institution.

The so-called general science course usually taught in junior high school is no answer to the problem. It is simply a conglomeration of highly specialized facts and laws of physics, chemistry and biology. Preparation for general living in this world of ours requires a high development of scientific thinking and a grasp of the fields of biology, chemistry and physics. Each of the courses should be part of general education, but they should be written with a view to the needs and uses of the eighty per cent, rather than the twenty per cent. It is ridiculous to suggest that these fields of study be eliminated from general education. It is not ridiculous to hope they may be revised, along with their accompanying textbooks, to bring them more in line with the demands of general education.

Once, as a small boy, the writer went on a camping trip. An old woodsman took a group of us on a hike. During the course of the hike he told us how to measure the distance across a stream while standing on one bank. He did not know and we did not know that he was teaching geometry. This was geometry for general education rather than the highly specialized geometry which most of us struggled through in high school and were never able to apply in our daily lives. We also spent long tedious hours parsing Latin words, a training well calculated to prepare us for the highly specialized work of philology. Very little time was spent developing an understanding of the social doctrines of great Latin writers. It was many years later that some

of us discovered the significant social doctrines contained in the orations of Cicero, when we read the Oxford English translations of those famous speeches.

The high school of yesterday was a college preparatory institution. That was in the days when most children quit school at the end of the eighth grade. The situation is entirely different today. Not only the bright and the average, but even the dull must today attend high school. They are still being called upon to struggle through college preparatory material, which is too difficult and has little significance for eighty per cent of them. The vain struggle to master specialized facts consumes so much time that the non-college students never learn even the basic scientific facts, nor gain the fundamental understandings of which they are capable. They struggle through a college preparatory chemistry course, forget most of it on graduation, and never understand the place of chemistry in daily life, nor its contribution to the social inheritance of mankind. The need is to recognize and define the true purposes of general education, and to revise our courses and rewrite our text books in biology, physics and chemistry, so as to achieve these purposes. The need is to face the fact that the American high school is no longer a college preparatory institution. ●

Program in Mathematics

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gaining ground that the present situation cannot be allowed to go on. Wide publicity should be given to statements such as the following, recently written by Colonel W. E. Sewell of the War Department:

> "Mathematics has gradually been removed from the various curricula until there is very little left that is useful or even recognizable. Many of the courses which are called mathematics are a disgrace to the name. They are designed for amusement, and anything which might be thought-provoking is carefully avoided.
>
> "It is difficult to understand why such a purge could take place in the face of the trend of modern civilization. The old arguments for studying mathematics were that it developed logical processes which were useful in practically every walk of life and that it was indispensable for many trades and professions. These arguments are certainly just as valid today as they ever were. Furthermore, the present emphasis on science and technology makes a knowledge of some mathematics necessary if one is to understand, even superficially, the foundation of modern progress.
>
> "Notwithstanding, arithmetic and algebra have been placed in the high school museum, and college courses in mathematics have been retained for those few who want to study science or engineering. The only way to put the subject back in its proper place in college is to replace it in the high school curriculum."[17]

It should be restated, also, that nothing in the pages of this article is intended to conflict with a due regard for the bona fide "functional demands of everyday life." Nevertheless, let the advocates of *mere* "practicality" peruse carefully what so eminent an authority as Professor A. N. Whitehead has to say on this subject. To quote:

> "The death of Archimedes by the hands of a Roman soldier is symbolical of a world-change of the first magnitude: the theoretical Greeks, with their love of abstract science, were superseded in the leadership of the European world by the practical Romans. Lord Beaconsfield, in one of his novels, has defined a practical man as a man who practises the errors of his forefathers. The Romans were a great race, but they were cursed with the sterility which waits upon practicality. They did not improve upon the knowledge of their forefathers, and all their advances were confined to the minor technical details of engineering. They were not dreamers enough to arrive at new points of view, which could give a more fundamental control over the forces of nature. No Roman lost his life because he was absorbed in the contemplation of a mathematical diagram."[18]

The same thinker reminds us that

> "The greatest revolution in *scientific* thought has come during the past fifty years in physics and mathematics. It has taught us the childishness of nineteenth-century materialism, it has taught us the reality of *value*."[19]

What, then, we may ask in conclusion, are the immediate demands thrust upon us by this "revolution," and especially by the momentous world-shaking consequences of the release of atomic energy? None other than Professor Albert Einstein, whose creative work did so much to prepare the way for the atomic age, has commented with great force on this all-important issue. He said, in part,

"A new type of thinking is essential if mankind is to survive and move to higher levels. . . . Our defense is not in armaments, nor in science, nor in going underground. *Our defense is in law and order."*[20]

Now, is there any school subject which more persistently extols and exemplifies the universal significance of honest thinking than does mathematics? The concepts of "law" and "order" are part of the very texture of mathematics. And so, if the mathematical program remains in touch with this great reservoir of understanding, it meets the most profound challenge of our day and thus contributes to the highest type of "functional competence in mathematics." ●

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    (2) "The Second Report of The Commission on Post-War Plans," in *The Mathematics Teacher*, May, 1945.
    (3) "General Education in a Free Society," report of the Harvard Committee, Harvard University Press, 1945.
13. McKay, Herbert, "Odd Numbers," Cambridge University Press, 1944, pp. 122-123.
14. For a most valuable discussion of the absolute necessity of providing a good mathematical foundation for all work in applied mathematics see Keal, Harry M., "The Philosophy of Technical Education", in *School Science and Mathematics*, January, 1944, pp. 12 ff.

15. How far certain groups of educators wish to extend the doctrine of "life situations and experiences", may be inferred from publications such as the following:
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    (2) *Living, the Basis for Learning*, from the Santa Barbara City Schools Curriculum Laboratory, published by Educational Factors, Santa Barbara, California, 1942.
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17. See, "Matnematics in the Army Education Program," by Colonel W. E. Sewell, Chief, Education Branch, Information and Education Division, War Department, in *The American Mathematical Monthly*, April, 1947, pp. 195-200.
18. Whitehead, A. N., *An Introduction to Mathematics*, pp. 40-41, Henry Holt and Company, 1911.
19. See *The American Scholar*, Winter 1947-48, p. 86.
20. From an interview published in *The New York Times Magazine*. (Reprints may be obtained from the Emergency Committee of Atomic Scientists, Princeton, New Jersey.)

Fire Prevention

(Continued from Page 39)

Thin glass is installed in skylights, so excessive heat from a fire will break the glass and permit escape of heat upward through the roof, to prevent pressure from building up and sending the hot gases into corridors and rooms.

The principle of heat removal is also seen in the use of insulating material to surround the air ducts of heating systems, furnaces, and steam pipes. The purpose of such insulation is to separate heat from combustible materials.

Removal of oxygen: Laboratory demonstrations easily show how carbon dioxide or carbon tetrachloride vapor will put out a flame, through supplanting the oxygen around it. In fire fighting, this principle is the basis of carbon dioxide and carbon tetrachloride extinguishers. Foam extinguishers, too, cover burning materials and exclude air, as well as cool the materials. In fire prevention, this principle is the basis of the handling of most flammable liquids and gases. By keeping them in air-tight containers, such gases and liquids are safe to handle and transport. Highly flammable fluids, such as gasoline, are handled at high temperatures with reasonable safety in many industrial processes, particularly oil refining. The secret, of course, is absolute exclusion of air from the liquid or vapor.

To show more effectively how these principles are applied, a field trip to one of the most modern fire-resistant buildings in the vicinity of a school could be arranged. Probably a member of the local fire department will serve as a guide. Students could be shown the fire-safety features, such as automatic sprinklers, water curtains, fire partitions, fire doors, and shaft enclosures which are built into modern construction as the result of long and sometimes tragic experience in fire-fighting, and careful analysis of fire damage.

To relate the classroom discussion more closely to the students' homes, several home-work projects may be suggested. Have students make a tour of their homes to list all possible sources of fire. Such a list would include the furnace, water heater, cooking stove, electric appliances, wiring, flues, fireplace, matches, cigarets, incinerator, and even static electricity sparks. Then ask them to list any features of their homes which they recognize as being desirable from a fire prevention point of view, as well as another list of features which may facilitate the start or spread of fire. Information concerning these desirable or undesirable features may be obtained in the National Board of Fire Underwriters' booklet, "60 Ways to Prevent Fire in Your Home."

While it is important that students get a better understanding of the causes and nature of fire, probably no impression could be of greater usefulness than that fire is a power not to be slighted. Its extinguishment or control requires the ingenuity of experienced men. Hence, in case of fire in the home, school, or church, the first thing to do is to notify the men especially trained in fighting it—the local fire department. Next should come the orderly evacuation of the building. Then, and only then, should amateurs attempt to cope with incipient fires. ●

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A bibliography of supplementary reading, tests, and instructional aids will be supplied to teachers on request. Address the Editor.